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ABSTRACT

This instructor's manual provides an outline and guide for teaching Wastewater Treatment I. It consists of nine sections. An introductory note and a course outline comprise sections 1 and 2. Section 3 (the bulk of the guide) presents lesson outlines for teaching the ten chapters of the manual entitled "Operation of Wastewater Treatment Plants." Topics covered in the lesson outlines are treatment plant operation; reasons for treating wastes; wastewater facilities; racks, screens, and comminutors; grit removal; sedimentation and flotation; trickling filters; rotating biological contactors; activated sludge; waste treatment ponds; and disinfection and chlorination. Each lesson outline contains a list of objectives, discussion of the relative importance of material to be presented, and suggestions for three-hour labs involving field trips to local facilities. Suggested handout materials, transparency masters, and visual aids are included in sections 4-6. The final three sections consist of sample questions and answers for exams and finals, objective tests and answers, and discussion and review questions. (A corresponding student's guide is available separately through ERIC--see note.) (MN)

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CE 028 907

WASTEWATER TREATMENT I

INSTRUCTOR'S MANUAL

Prepared by

Joint Education Committee
of the
California Water Pollution Control Association
and the
California - Nevada Section, American Water Works Association
in cooperation with
REMCON, INC.
and
Contra Costa Community College
for the
California Community Colleges

1979

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for a monumental task very well accomplished.

Kenneth T. Jackson
Associate Director of
Technical and Industrial Education
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I. TO THE INSTRUCTOR

This "Instructor's Manual" was prepared to provide you with an outline and a guide for teaching Wastewater Treatment I. The objective of the material is to help you provide your students with the knowledge and skills they need to obtain a job and advance in the field of wastewater treatment.

Course objectives as well as objectives for each class meeting are provided in this manual. An outline for each class indicates the important material that should be covered. Each page is divided in half with topics on the left half and ample space on the right half for you to insert your own notes. Emphasis should be placed on the tasks your students will actually be performing on the job. Whenever possible, stress local conditions so your students can relate to the material. If your students have the Student's Guide, they will have the same course outline with space for their own notes.

Consideration must be given to the background and career objectives of your students. Students in this course should be working in wastewater treatment plants or preparing themselves to work in plants. If your students are persons who are working in a wastewater treatment facility, they are familiar with the physical layout and the mechanical equipment and meters in their facility. Students preparing to enter the field should be provided the opportunity to visit wastewater treatment plants. One three-hour lab session per week in a treatment plant would be most helpful for these students. Class activities are suggested if your program includes lab sessions in treatment plants.

Operators working in treatment plants will be concerned with the physical, chemical and biological aspects of wastewater and wastewater treatment plants. They will want to know why something happens and how it can be regulated or controlled. Try to encourage experienced operators to share their experience with the class. Students who are looking for an opportunity to work in a wastewater treatment plant may not be familiar with the physical layout and equipment in a treatment plant. These students will require a different emphasis in addition to needing to know why something happens and how it can be regulated or controlled. Remember, students need to know how to do the jobs done by people working in wastewater treatment plants. Students completing this course should be able to pass the Grade I and probably the Grade II Operator Certification Exams administered by the California State Water Resources Control Board.

Material in this manual includes:

1. Lesson outlines;
2. Suggested handout material;
3. Material that may be converted to transparencies;
4. Sample questions for exams and finals; and
5. List of visual aids.

You should select the best instructional approach for teaching this material on the basis of your experience, your students' backgrounds, available time, and the instructional facilities available. Learning may be accomplished by using lecture, discussion, demonstration, exercises and field trips. Feel free to adjust the material and schedule to meet the needs of your students.

The lesson outlines follow the manual, Operation of Wastewater Treatment Plants, prepared by and available from Dr. Kenneth D. Kerri, Professor of Civil Engineering, California State University, Sacramento, 6000 "J" Street, Sacramento, California 95819. The actual material was written by operators of wastewater treatment plants on the basis of what they believe operators need to know to do their jobs. Funds for the development of the manual were provided by the U. S. Environmental Protection Agency in cooperation with the California Water Pollution Control Association. The first edition was published in 1970 and has been updated almost every year when more manuals were printed. The first draft of the second edition has been completed. Where appropriate, the outlines will indicate the appropriate sections in both the first and second editions. Table I lists the Chapters in the First Edition and Table II lists the Chapters in the Second Edition.

Table III, List of Performance Tasks, Skills, Knowledge from CCCC (Charles County Community College, La Plata, Maryland) "Job Analysis" Process Control, illustrates the depth of skills and knowledge operators need to know to do their job. This material was developed for the U. S. Environmental Protection Agency to serve as a guide for persons developing training materials. Remember that equipment manufacturers are always attempting to improve their products by developing newer and better equipment. For these reasons operators often must rely on equipment manufacturers for details on how to start up, operate, maintain, repair and shut down complex pieces of equipment.

TABLE I. CHAPTERS IN THE FIRST EDITION OF OPERATION OF WASTEWATER TREATMENT PLANTS

CHAPTER	TOPIC
1.	Introduction
2.	Why Treat Wastes?
3.	Wastewater Facilities
4.	Racks, Screens, Comminutors and Grit Removal
5.	Sedimentation and Flotation
6.	Trickling Filters
7.	Activated Sludge
8.	Sludge Digestion and Handling
9.	Waste Treatment Ponds
10.	Disinfection and Chlorination
11.	Maintenance
12.	Plant Safety and Good Housekeeping
13.	Sampling Receiving Waters
14.	Laboratory Procedures and Chemistry
15.	Basic Mathematics and Treatment Plant Problems
16.	Analysis and Presentation of Data
17.	Records and Report Writing
	Glossary

TABLE II. CHAPTERS IN THE SECOND EDITION OF OPERATION OF WASTEWATER TREATMENT PLANTS

CHAPTER	TOPIC
	VOLUME I
1.	The Treatment Plant Operator
2.	Why Treat Wastes?
3.	Wastewater Treatment Facilities
4.	Racks, Screens, Comminutors and Grit Removal
5.	Sedimentation and Flotation
6.	Trickling Filters
7.	Rotating Biological Contactors
8.	Activated Sludge (Part I. Package Plants and Oxidation Ditches)
9.	Waste Treatment Ponds
10.	Disinfection and Chlorination
	Glossary
	VOLUME II
11.	Activated Sludge (Part II. Conventional Activated Sludge Plants)
12.	Sludge Digestion and Solids Handling
13.	Effluent Disposal
14.	Plant Safety and Good Housekeeping
15.	Maintenance
16.	Laboratory Procedures and Chemistry
17.	Basic Arithmetic and Treatment Plant Problems
18.	Analysis and Presentation of Data
19.	Records and Report Writing
	Glossary

TABLE II. (Con'd)

CHAPTER	TOPIC
	VOLUME III
20.	Odor Control
21.	Activated Sludge (Part III. Pure Oxygen & Operational Control Alternatives)
22.	Solids Handling and Disposal
23.	Solids Removal from Secondary Effluents
24.	Phosphorus Removal
25.	Wastewater Reclamation
26.	Instrumentation
27.	Industrial Waste Monitoring
28.	Industrial Waste Treatment
29.	Support Systems
	Glossary

TABLE III. LIST OF PERFORMANCE TASKS, SKILLS KNOWLEDGE FROM CCCC "JOB ANALYSIS" PROCESS CONTROL

1. Identify the device or equipment.
2. Describe the device or equipment:
   - 2A. Purpose (how it affects the wastestream)
   - 2B. How it affects aeration, digestion, grit removal, primary sedimentation, pumping & piping, solids disposal, trickling filtration, etc.
3. Identify the components of a specific device or equipment from (1) above.
4. Describe each component with respect to:
   - 4A. Function (operation and purpose)
   - 4B. Importance of each function
5. Name and locate the components of the device/equipment from (1) above.
6. Describe safety procedures for the device/equipment:
   - 6A. High risk activities
   - 6B. Sources of danger
   - 6C. Safety equipment and purpose
7. Describe the normal operation procedures for each component:
   - 7A. Describe the characteristics of each component to check
   - 7B. Identify normal/abnormal conditions/indicators
   - 7C. Explain how often each component must be checked and why
   - 7D. Describe operator actions required if conditions/indicators are abnormal: adjustments, corrective maintenance, report to supervisor, report in writing
   - 7E. Explain why component's characteristics must be returned to normal
   - 7F. Describe the routine sampling for the device/equipment
   - 7G. Describe the routine calculations for the device/equipment
   - 7H. Describe the routine procedures for recording data
8. Describe the start-up and shut-down procedures for the device/equipment:
   - 8A. Describe the start-up procedure
   - 8B. Describe the shut-down procedure
   - 8C. Evaluate whether correct start-up procedures have been used
   - 8D. Evaluate whether correct shut-down procedures have been used

TABLE III. (Con'd)

9. Describe the abnormal operation procedures for the device/ equipment:
    - 9A. Evaluate the wastestream for abnormal conditions: amount of floating and suspended material, velocity and level of the flow, the waste characteristics, the high and low range of acceptable value for each characteristic
    - 9B. Describe the cause and effect of the abnormal condition
    - 9C. Explain how often the condition of the wastestream must be checked
    - 9D. Describe what an operator does if abnormal conditions observed: operational changes, reporting to supervisor, sampling procedures
    - 9E. Describe how the actions of the operator will improve the condition of the wastestream

10. Describe the preventive maintenance procedures for the device/ equipment:
    - 10A. Describe pertinent procedures, such as: cleaning, painting, lubrication, mechanical adjustment, replacement, wear measurement, etc
    - 10B. Name the reference materials and tools needed for each preventive maintenance procedure in 10A
    - 10C. Explain how often each preventive maintenance procedure must be performed
    - 10D. Explain what an operator does if a component needs preventive maintenance
    - 10E. Explain how an operator determines whether a component needs preventive maintenance
    - 10F. Explain why each preventive maintenance procedure is important

11. Describe the corrective maintenance procedures for the device/ equipment:
    - 11A. Describe how an operator evaluates each component for corrective maintenance: capacity, color, corrosion, depth, deterioration, flow, motion, odor, position, sound, temperature, vibration, etc
    - 11B. Explain why a component has malfunctioned
    - 11C. Name the reference materials and tools needed to perform the corrective maintenance
    - 11D. Describe what an operator does when a malfunction is discovered: evaluation of capabilities of plant personnel to perform the procedures, selection of replacement parts, record keeping
    - 11E. Describe how the operator corrects the malfunction

II. COURSE OUTLINE

WASTEWATER TREATMENT I

WEEK	TOPIC
1.	Class Procedures The Treatment Plant Operator
2.	Why Treat Wastes?
3.	Wastewater Treatment Plants
4.	Racks, Screens, Comminutors and Grit Removal
5.	Review, Exam, Return Exam and Critique
6.	Sedimentation and Flotation
7.	Trickling Filters
8.	Rotating Biological Contactors
9.	Review, Exam, Return Exam and Critique
10.	Activated Sludge Process
11.	Package Aeration Plants
12.	Oxidation Ditches
13.	Waste Treatment Ponds
14.	Disinfection
15.	Review, Exam, Return Exam and Critique
16.	Disinfection, Review Course
17.	Final Exam

WASTEWATER TREATMENT II
TENTATIVE COURSE OUTLINE

WEEK	TOPIC
1.	Class Procedures Review of Wastewater Treatment I
2.	Activated Sludge
3.	Activated Sludge
4.	Activated Sludge
5.	Review, Exam, Return Exam and Critique
6.	Sludge Digestion and Solids Handling
7.	Sludge Digestion and Solids Handling
8.	Effluent Disposal
9.	Plant Safety and Good Housekeeping
10.	Review, Exam, Return Exam and Critique
11.	Maintenance
12.	Maintenance
13.	Analysis and Presentation of Data
14.	Records and Report Writing
15.	Review, Exam, Return Exam and Critique
16.	Advanced Topics on Activated Sludge and Solids Handling Review Course
17.	Final Exam

III. LESSON OUTLINES

CHAPTER 1

THE TREATMENT PLANT OPERATOR

Week 1 **Hour** 1 **Chapter:**
Class Procedures

Lesson Outline	**Lecture Notes**

Objectives: Familiarize students with class procedures, course policy, grading, course objectives and topics covered.

Assignment: Objective test at end of Chapter 1 (due in one week).

Lecture Outline

1. Handouts (adjust example handouts to meet your needs).
    1. Course Policy
    2. Course Outline
2. Call roll. Admit new students
3. Course Objectives
    1. Provide students with the knowledge and skills needed to safely and effectively operate and maintain wastewater treatment plants.
    2. Develop new, qualified treatment plant operators.
    3. Expand abilities of existing operators of treatment plants.
    4. Prepare operators to pass certification examinations.
4. Grading and how final grade determined

Week 1 **Hour** 1 (Con'd) **Chapter:** Class Procedures

Lesson Outline	Lecture Notes
5. Quizzes 6. Homework 7. Missed exams and quizzes 8. Examination procedures 9. Old exams 10. Examination critique 11. Dropping course 12. Final grade (How obtained) 13. Course Outline (See previous outline or handout) 14. Whenever a lesson outline for an hour is completed, continue with the next hour if time permits.	

Week 1 **Hour** 2 **Chapter:** 1
The Treatment Plant Operator

Lesson Outline	**Lecture Notes**
Objective: Describe duties of an operator and job opportunities. Lecture Outline 1.0 What is a treatment plant operator? 1.1 Your personal training program. 1.2 What do you already know? 1.3 The water quality protector: YOU 1.4 Your qualifications. 1.5 Manpower needs and future job opportunities. 1. How to obtain jobs at local treatment plants. Persons to contact: Name____________________ Address____________________ Phone Number________________ 2. Job opportunities____________ 3. Starting & future salaries_____ 1.6 Training yourself to meet the needs. 1. Operator publications a. Water Pollution Control Federation Deeds & Data b. California Water Pollution Control Association Bulletin	

Week 1 **Hour** 2 (Con'd) **Chapter:** 1
The Treatment Plant Operator

Lesson Outline	Lecture Notes
2. California Water Pollution Control Association training conferences, short schools and workshops.	

Week 1 **Hour** 3 **Chapter:** 1
The Treatment Plant Operator

Lesson Outline

Objective: Determine how to qualify, apply and pass operator certification exams.

Lecture Outline

1. Types of plants requiring various levels of certification.
2. Qualifications necessary to apply for certification exams.
3. How to apply for certification exams.
4. How to study for certification exams.
5. Typical types of exam questions.
6. Comments by students who have taken exams.

Lecture Notes

Week 1 3- **Hour** Lab (Optional) **Chapter:** 1 The Treatment Plant Operator

Lesson Outline

Objectives: Visit a wastewater treatment plant and become familiar with the flow paths of water and solids.

Assignment:

1. Describe purpose of each treatment process and how it works.
2. Prepare a list of tasks done by operators.

Lecture Notes

CHAPTER 2

WHY TREAT WASTES?

Week 2 **Hour** 1 **Chapter:** 2
Why Treat Wastes?

Lesson Outline

Objective: Describe characteristics of wastes and why wastewater must be treated.

NOTE: Outline for Week 2 may be condensed into one hour if instructor and students are anxious to devote their time in the actual operation of treatment plants.

Assignment: Objective test at end of Chapter 2.

Lecture Outline

Pronunciation Guide

Glossary: Discuss new words

2.0 Prevention of Pollution

1. Protect public health (drinking and swimming) and aquatic life from poisons and diseases (fishing and birds)
2. Protect beneficial uses of water such as municipal and industrial water supplies, irrigation, navigation and recreation.

2.1 What is Pure Water?

1. Distilled water
2. Rain Water
3. Sea water conversion

Lecture Notes

Week 2 **Hour** 1(Con'd) **Chapter:** 2
Why Treat Wastes?

Lesson Outline

4. Reclaimed wastewater

2.2 Types of Waste Discharges

1. Municipal
2. Industrial
3. Agricultural runoff
    a. Feed lots and dairies
    b. Irrigation
4. Storm water runoff
5. Point and nonpoint sources
6. Types of wastes
    a. Organic
    b. Inorganic
    c. Thermal
    d. Radioactive

Lecture Notes

Week 2 Hour 2 Chapter: 2
Why Treat Wastes?

Lesson Outline	Lecture Notes
Objective: Describe characteristics of wastes and why wastewater must be treated.	

Lecture Outline

2.3 Effects of Waste Discharges

2.30 Sludge and Scum

1. Bottom sludge deposits
   a. Depletion of dissolved oxygen (DO) in stream.
   b. Cover plant life, aquatic organisms; fish food and spawing beds
2. Surface scum
   a. Unsightly (evidence of pollution) scums and floatables
   b. Reduces surface re-aeration and sunlight penetration of water for photosynthesis
3. Both sludge and scum exert a detrimental impact on oxygen resources of a stream or river that are essential for fish life

Week 2 Hour 2(Con'd) **Chapter:** 2
Why Treat Wastes?

Lesson Outline	**Lecture Notes**
2.31 Oxygen Depletion 1. Aquatic organisms, including fish, require sufficient dissolved oxygen (DO) in their aquatic environment for survival. 2. Respiration (breathing) removes oxygen (DO) from water. 3. The more food (wastes) in water, the more active (higher respiration and reproduction rates) become the aquatic organisms. If the oxygen supply is not replenished, the aquatic organisms and fish could die from lack of oxygen (just like people) 4. If there is no dissolved oxygen (DO) in water, anaerobic bacteria thrive	

Week 2 **Hour** 2 (Con'd) **Chapter:** 2
Why Treat Wastes?

Lesson Outline

5. Define anaerobic bacteria
6. Anaerobic bacteria decompose wastes and produce undesirable odors (hydrogen sulfide gas, H_2S)
7. Hydrogen sulfide gas is very dangerous.
    a. H_2S smells like rotten eggs. Your nose quickly gets tired of smelling this odor and before long you can no longer detect the presence of hydrogen sulfide gas.
    b. Hydrogen sulfide is a toxic gas that can kill you by paralyzing your respiratory center.
    c. Hydrogen sulfide gas can kill you because it is explosive and flammable
    d. Hydrogen sulfide gas can kill you by accumulating in a confined space

Lecture Notes

Week 2 **Hour** 2 (Con'd) **Chapter:** 2
Why Treat Wastes?

Lesson Outline

Lecture Notes

until there is insufficient oxygen in the atmosphere for you to breathe.

e. The safety record of people working in the wastewater treatment industry is one of the worst of any industry in the United States.

2.32 Human Health

1. Viruses
2. Diseases
3. Poison or toxic substances

2.33 Other Effects

1. pH
    a. Define pH
    b. Impact of high or low pH on aquatic life and industrial water users
2. Toxic substances (impact on aquatic life)
    a. Heavy metals
    b. Cyanide
    c. Chlorine residual in effluent

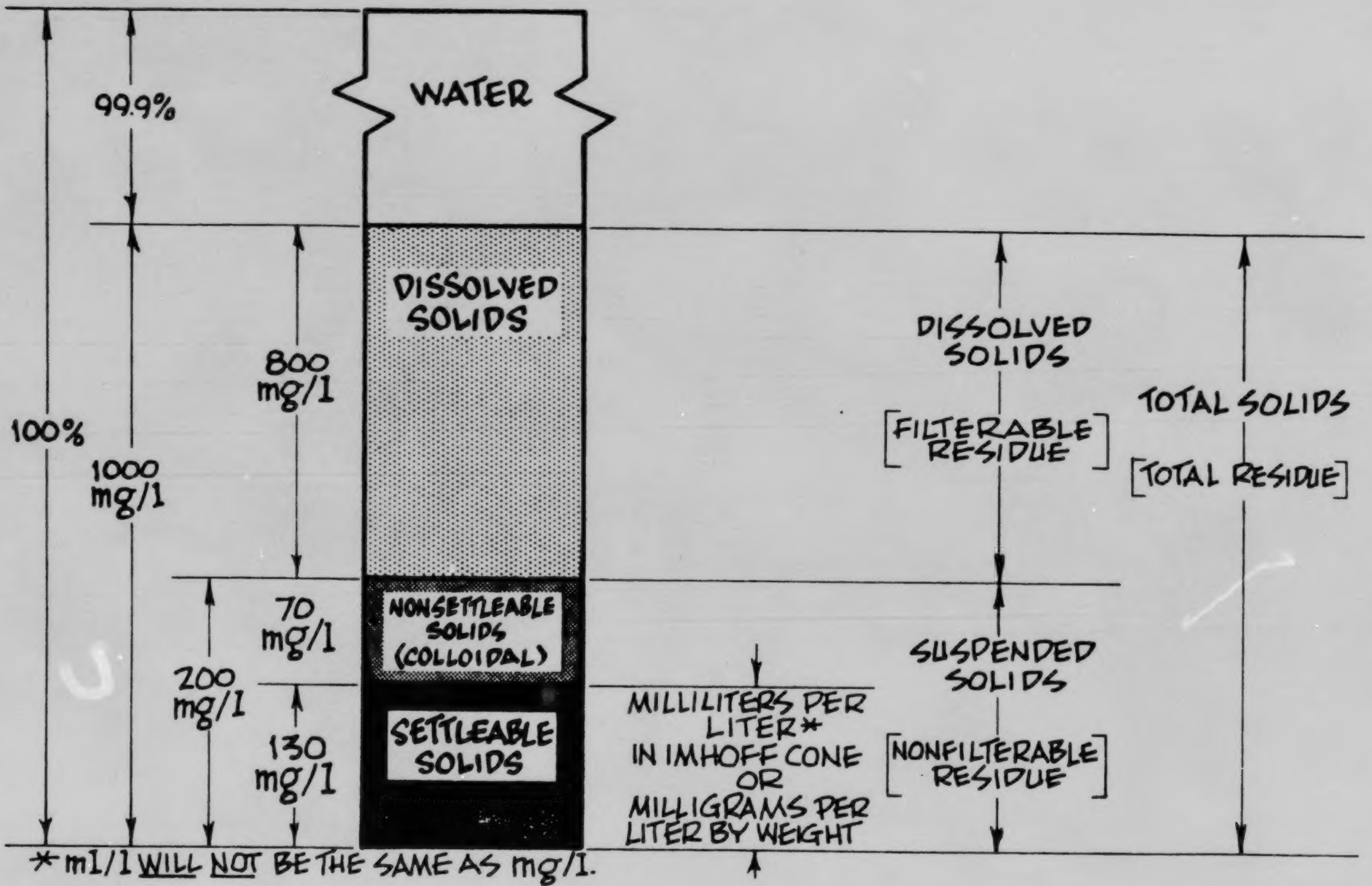
Week 2 **Hour** 2 (Con'd) **Chapter:** 2
Why Treat Wastes?

Lesson Outline	**Lecture Notes**
3. Tastes and odors 4. Nutrients	

Week 2 **Hour** 3 **Chapter:** 2
Why Treat Wastes?

Lesson Outline	**Lecture Notes**
Objective: Describe characteristics of wastes and why wastewater must be treated.	
Lecture Outline	
2.4 Solids in Wastewater	
Refer to Figure 1, composition of solids in raw wastewater.	
2.40 Types of Solids (define and describe terms)	
1. Suspended and dissolved solids	
2. Organic and inorganic solids	
2.41 Total Solids	
1. How measured	
2. Dissolved and suspended solids	
2.42 Dissolved Solids	
1. How measured	
2. Filterable residue	
2.43 Suspended Solids	
1. How measured	
2. Nonfilterable residue	
3. Settleable solids	
2.44 Organic and Inorganic Solids	
1. Organic solids are of animal or vegetable origin and	

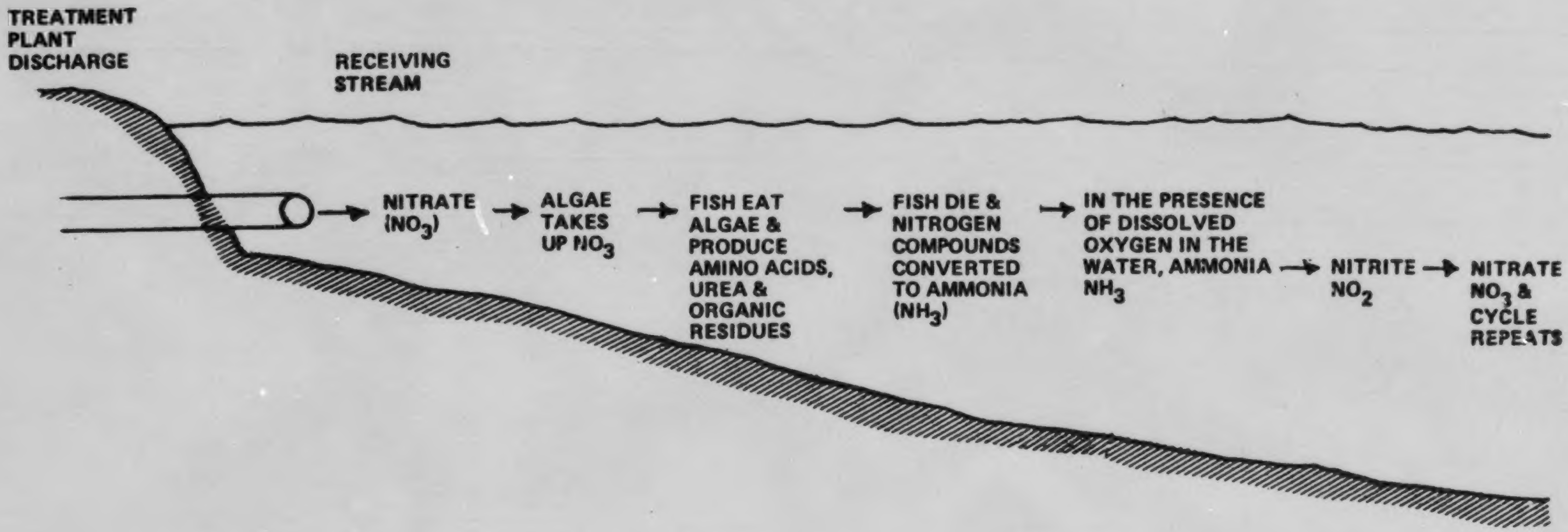
Fig. 1
15


WATER
99.9%
100%
1000 mg/l
DISSOLVED SOLIDS
800 mg/l
NONSETTLEABLE SOLIDS (COLLOIDAL)
70 mg/l
200 mg/l
SETTLEABLE SOLIDS
130 mg/l
MILLILITERS PER LITER* IN IMHOFF CONE OR MILLIGRAMS PER LITER BY WEIGHT
DISSOLVED SOLIDS
[FILTERABLE RESIDUE]
SUSPENDED SOLIDS
[NONFILTERABLE RESIDUE]
TOTAL SOLIDS
[TOTAL RESIDUE]
*ml/l WILL NOT BE THE SAME AS mg/l.

Composition of solids in raw wastewater

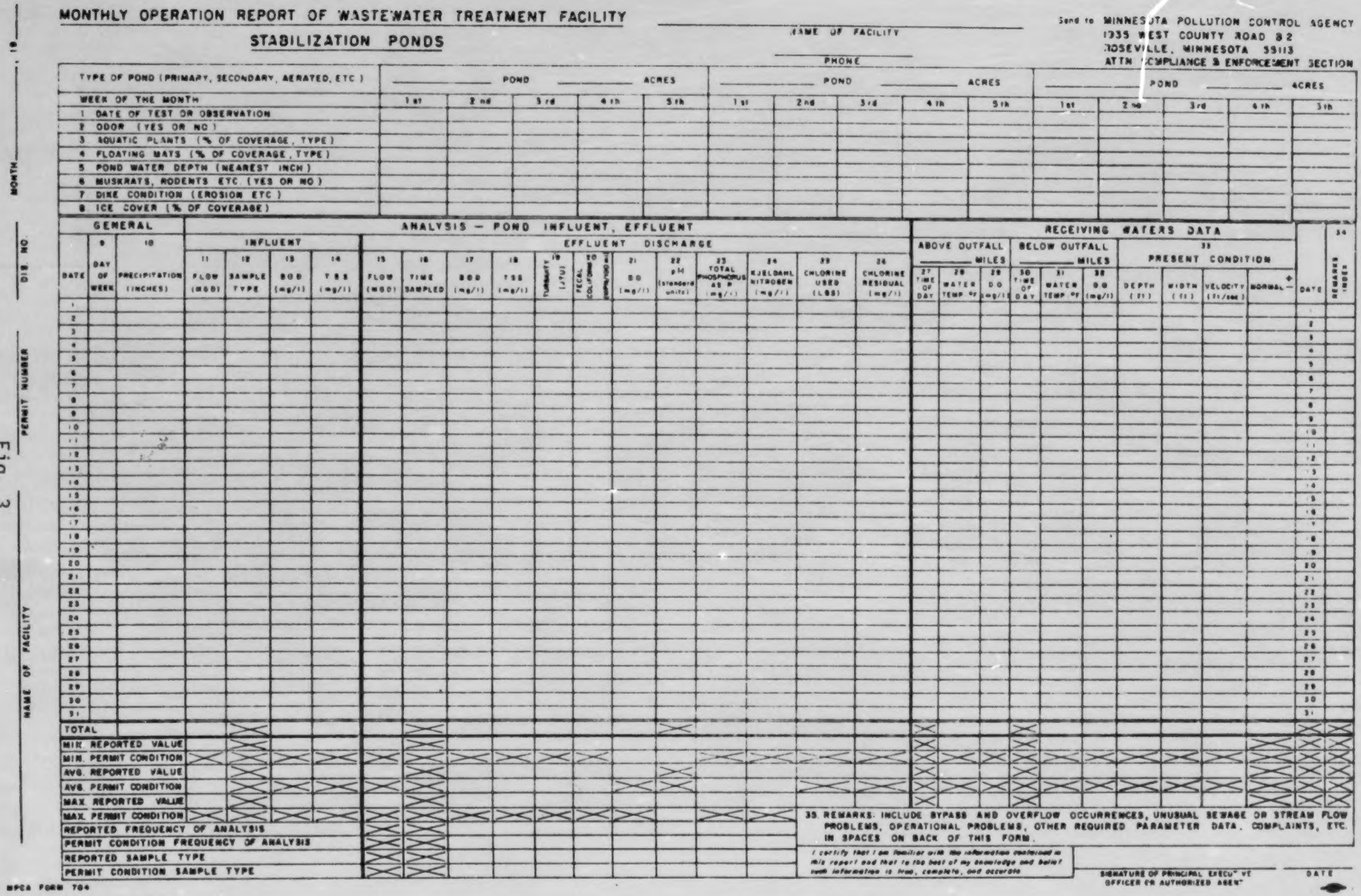
Lesson Outline	**Lecture Notes**
twice provide food for aquatic organisms 2. Inorganic solids are of mineral origin and serve as nutrients for aquatic plants, including algae 2.45 Floatable Solids 2.5 Natural Cycles (Second Edition only) Refer to Figure 2, simplified illustration of nitrogen cycle. 1. Factors influencing damages caused by the discharge of treated wastewaters on receiving waters 2. Natural cycles Natural purification cycle, cycle of water, life cycles of aquatic organisms, and nutrient cycles 3. Nutrient cycles Carbon, hydrogen, oxygen, sulfur, nitrogen and phosphorus 4. Nitrogen cycle a. Refer to Figure 2, simplified illustration of nitrogen cycle on next page.	

Fig. 2
17


TREATMENT PLANT DISCHARGE
RECEIVING STREAM
NITRATE (NO_3)
ALGAE TAKES UP NO_3
FISH EAT ALGAE & PRODUCE AMINO ACIDS, UREA & ORGANIC RESIDUES
FISH DIE & NITROGEN COMPOUNDS CONVERTED TO AMMONIA (NH_3)
IN THE PRESENCE OF DISSOLVED OXYGEN IN THE WATER, AMMONIA NH_3
NITRITE NO_2
NITRATE NO_3 & CYCLE REPEATS

Simplified illustration of nitrogen cycle

Lesson Outline	Lecture Notes
b. Under aerobic conditions (DO present) nitrogen compounds converted to nitrate (NO_3^{-1}, an ion containing oxygen). Other ions created under aerobic conditions include sulfate (SO_4^{-2}) and phosphate (PO_4^{-3}) c. Under anerobic conditions (no DO present) nitrogen compounds converted to ammonium (NH_4^+, an ion containing no oxygen). Other compounds created under anaerobic conditions include hydrogen sulfide (H_2S) and methane (CH_4). 2.6 NPDES Permits (Second Edition only) Refer to Figure 3, Typical NPDES permit reporting form. 1. National Pollutant Discharge Elimination System (NPDES) 2. Water quality indicators specified 3. Monthly average and maximum levels	



MONTH ________, 19__

DIS. NO. ________

PERMIT NUMBER ________

NAME OF FACILITY ________

MONTHLY OPERATION REPORT OF WASTEWATER TREATMENT FACILITY

STABILIZATION PONDS

________ NAME OF FACILITY

________ PHONE

Send to MINNESOTA POLLUTION CONTROL AGENCY
1935 WEST COUNTY ROAD B 2
ROSEVILLE, MINNESOTA 55113
ATTN COMPLIANCE & ENFORCEMENT SECTION

TYPE OF POND (PRIMARY, SECONDARY, AERATED, ETC)	________ POND ________ ACRES					________ POND ________ ACRES					________ POND ________ ACRES				
WEEK OF THE MONTH	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
1 DATE OF TEST OR OBSERVATION															
2 ODOR (YES OR NO)															
3 AQUATIC PLANTS (% OF COVERAGE, TYPE)															
4 FLOATING MATS (% OF COVERAGE, TYPE)															
5 POND WATER DEPTH (NEAREST INCH)															
6 MUSKRATS, RODENTS ETC (YES OR NO)															
7 DIKE CONDITION (EROSION ETC)															
8 ICE COVER (% OF COVERAGE)															

GENERAL			ANALYSIS — POND INFLUENT, EFFLUENT																RECEIVING WATERS DATA											
			INFLUENT				EFFLUENT DISCHARGE												ABOVE OUTFALL ____ MILES			BELOW OUTFALL ____ MILES			33 PRESENT CONDITION					
DATE	9 DAY OF WEEK	10 PRECIPITATION (INCHES)	11 FLOW (MGD)	12 SAMPLE TYPE	13 BOD (mg/l)	14 TSS (mg/l)	15 FLOW (MGD)	16 TIME SAMPLED	17 BOD (mg/l)	18 TSS (mg/l)	19 TURBIDITY (JTU)	20 FECAL COLIFORM	21 DO (mg/l)	22 pH (standard units)	23 TOTAL PHOSPHORUS AS P (mg/l)	24 KJELDAHL NITROGEN (mg/l)	25 CHLORINE USED (LBS)	26 CHLORINE RESIDUAL (mg/l)	27 TIME OF DAY	28 WATER TEMP °F	29 D.O. (mg/l)	30 TIME OF DAY	31 WATER TEMP °F	32 DO (mg/l)	DEPTH (ft)	WIDTH (ft)	VELOCITY (ft/sec)	NORMAL + −	DATE	34 REMARKS INDEX
1																													1	
2																													2	
3																													3	
4																													4	
5																													5	
6																													6	
7																													7	
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30																													30	
31																													31	
TOTAL				☒				☒						☒					☒			☒							☒	☒
MIN. REPORTED VALUE				☒				☒											☒			☒						☒	☒	☒
MIN. PERMIT CONDITION			☒	☒	☒	☒	☒	☒	☒	☒	☒	☒			☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
AVG. REPORTED VALUE				☒				☒						☒					☒			☒						☒	☒	☒
AVG. PERMIT CONDITION				☒	☒	☒	☒	☒					☒	☒			☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
MAX. REPORTED VALUE				☒				☒											☒			☒						☒	☒	☒
MAX. PERMIT CONDITION			☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒		☒	☒														
REPORTED FREQUENCY OF ANALYSIS							☒	☒																						
PERMIT CONDITION FREQUENCY OF ANALYSIS							☒	☒																						
REPORTED SAMPLE TYPE							☒	☒																						
PERMIT CONDITION SAMPLE TYPE							☒	☒																						

35. REMARKS: INCLUDE BYPASS AND OVERFLOW OCCURRENCES, UNUSUAL SEWAGE OR STREAM FLOW PROBLEMS, OPERATIONAL PROBLEMS, OTHER REQUIRED PARAMETER DATA, COMPLAINTS, ETC. IN SPACES ON BACK OF THIS FORM.

I certify that I am familiar with the information contained in this report and that to the best of my knowledge and belief such information is true, complete, and accurate.

________ SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT

________ DATE

MPCA FORM 704

Fig. 3

Typical NPDES permit

Week 2 **Hour** 3(Con'd) **Chapter:** 2
Why Treat Wastes?

Lesson Outline

4. Review permit reporting form

2.7 Additional reading. Importance of being aware of other publications

2.8 Review

1. Objectives of wastewater treatment: Protect the receiving waters and downstream water users at the lowest possible costs.
2. Methods of accomplishing objectives

Lecture Notes

Week 2 **3- Hour** Lab (Optional) **Chapter:** 2 Why Treat Wastes?

Lesson Outline	**Lecture Notes**
Objective: Visit a different wastewater treatment plant than the one visited last week and become familiar with the flow paths of water and solids. Assignment: 1. Describe purpose of each treatment process and how it works. 2. Prepare a list of tasks done by the operators.	

CHAPTER 3

WASTEWATER FACILITIES

Week 3 **Hour** 1 **Chapter:** 3
Wastewater Facilities

Lesson Outline

Objectives:

1. Describe various types of wastewater treatment plants.
2. Draw schematic plan layouts of typical plants.
3. List major treatment processes and the purpose of each process.

Assignment: Objective test at end of Chapter 3 plus objectives 2 and 3 listed above.

Lecture Outline:

Glossary: Review new words

3.0 Collection, Treatment and Disposal

3.1 Collection of Wastewater

1. Pipes and pumps
2. Waste discharges
   a. Flows
   b. Waste characteristics
3. Impact of collection and transportation on wastewater characteristics and flows
4. Impact of stoppages and activities of sewer maintenance crews on wastewater characteristics and flows.

Lecture Notes

Week 3 **Hour** 1 (Con'd) **Chapter:** 3
Wastewater Facilities

Lesson Outline

Lecture Notes

3.10 Sanitary, Storm and Combined Sewers

1. Sanitary sewers
2. Storm sewers
3. Combined sewers
4. Infiltration

3.2 Treatment Plants

Refer to Fig. 4, Flow diagram of wastewater treatment processes

1. Discuss treatment processes and functions
2. Ponds (Fig. 4.a)
3. Trickling Filters (Fig. 4.b)
4. Activated Sludge (Fig. 4.c)

3.3 Pretreatment

3.30 Purpose

Separate coarse material from water being treated

3.31 Screening

Bar screens (manually cleaned and mechanically cleaned)

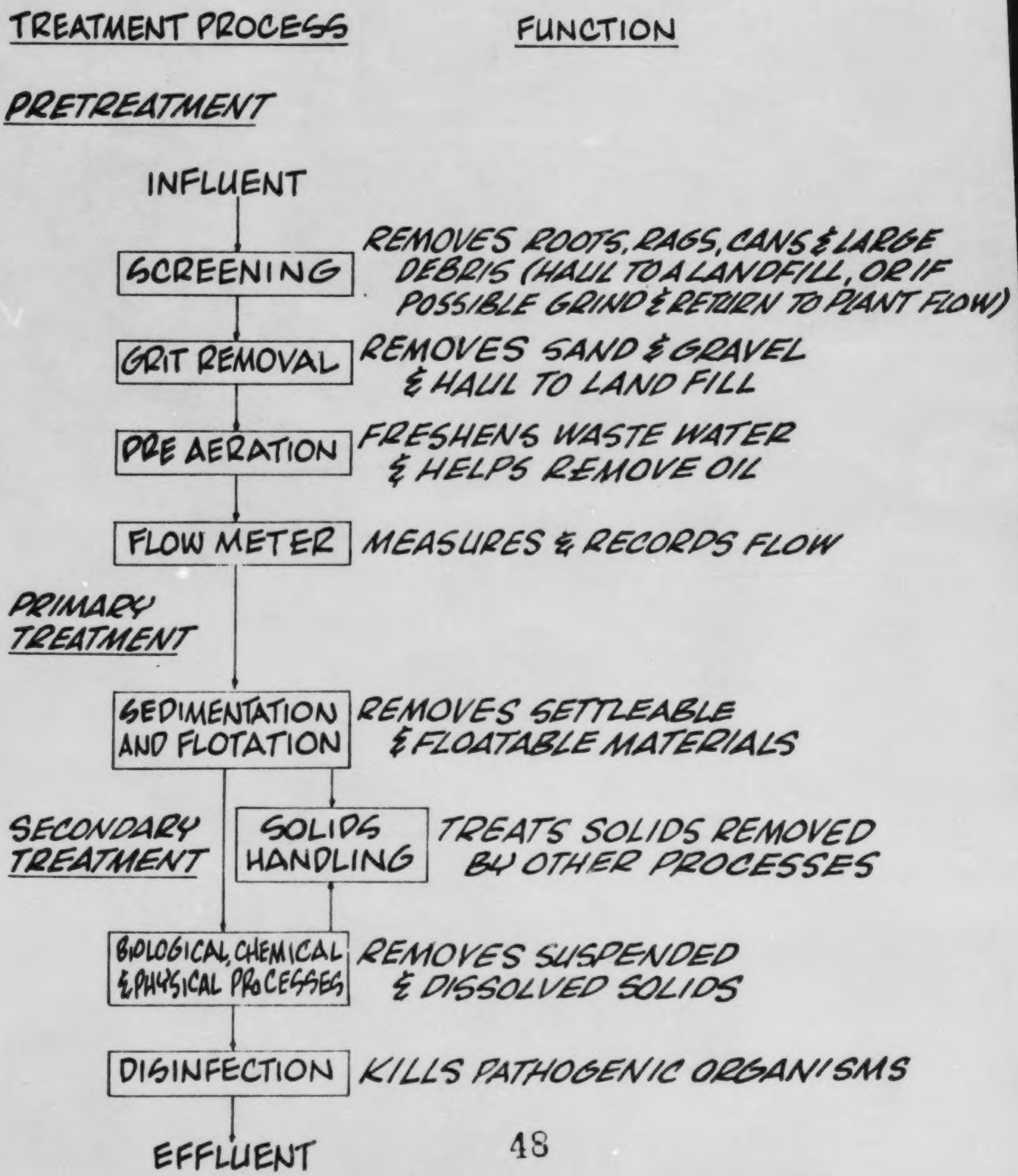
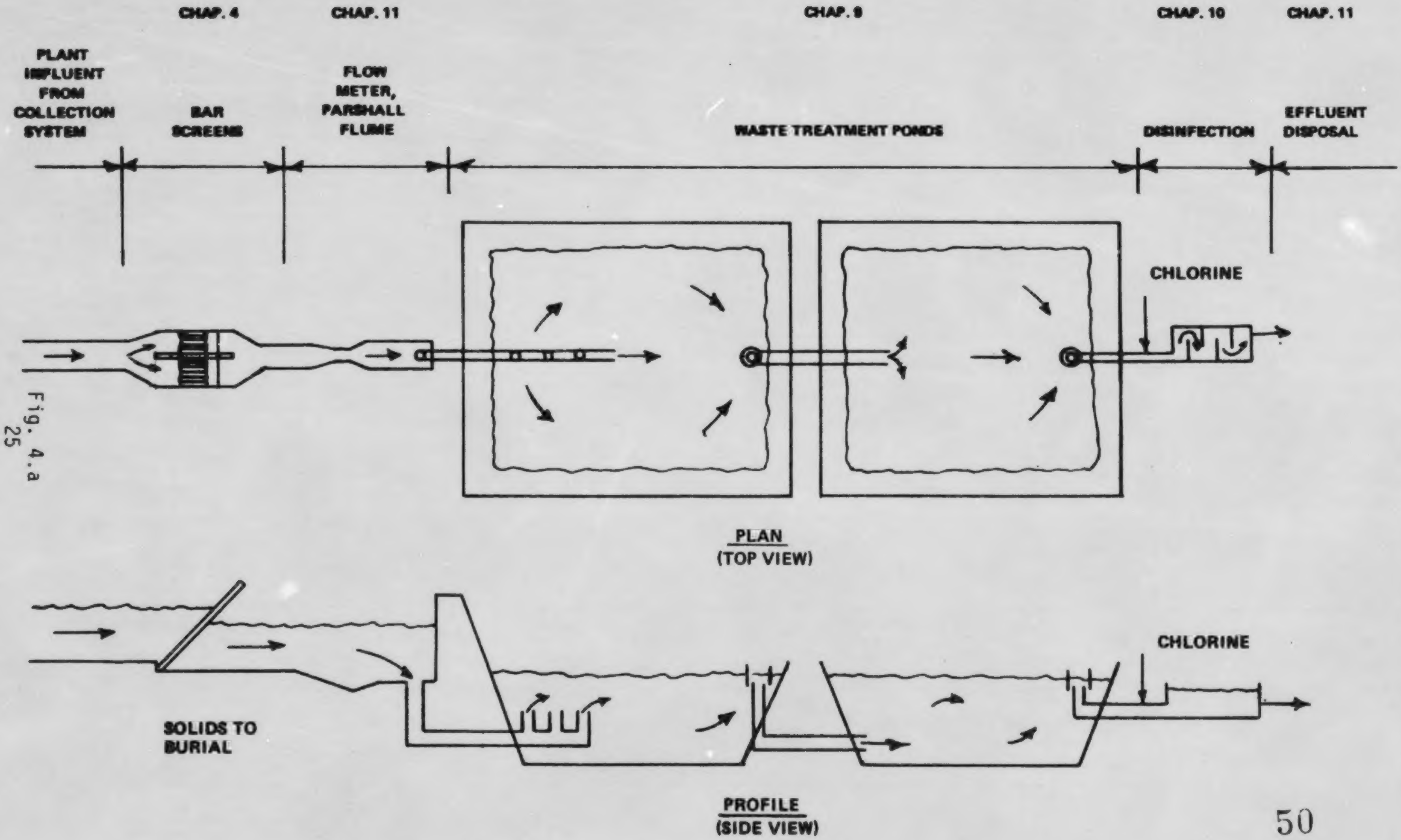

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

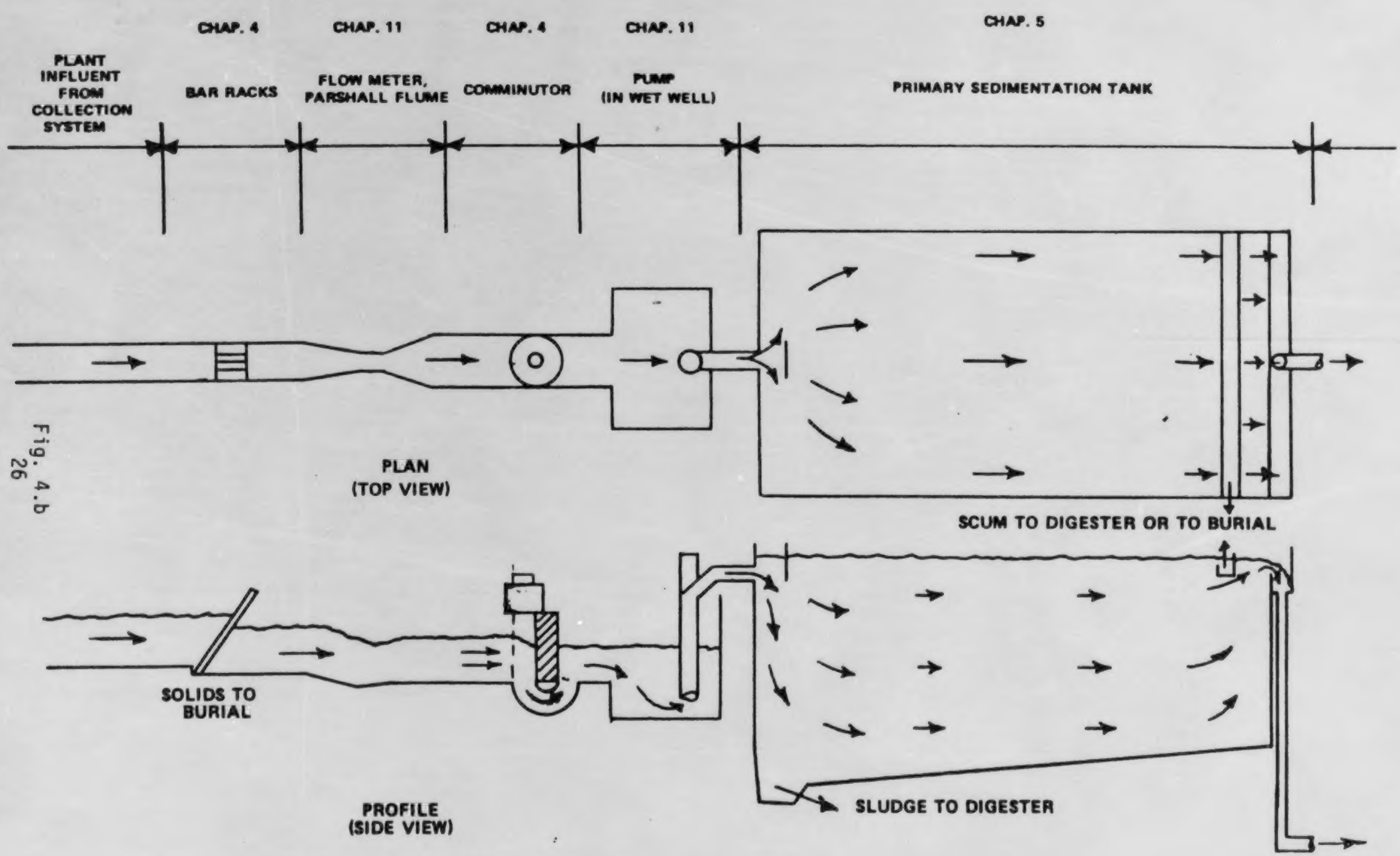
Fig. 4 Flow Diagram of Wastewater Treatment Processes

Fig. 4.a
25


CHAP. 4
CHAP. 11
CHAP. 9
CHAP. 10
CHAP. 11
PLANT INFLUENT FROM COLLECTION SYSTEM
BAR SCREENS
FLOW METER, PARSHALL FLUME
WASTE TREATMENT PONDS
DISINFECTION
EFFLUENT DISPOSAL
CHLORINE
PLAN (TOP VIEW)
CHLORINE
SOLIDS TO BURIAL
PROFILE (SIDE VIEW)

Possible flow pattern through a pond treatment plant

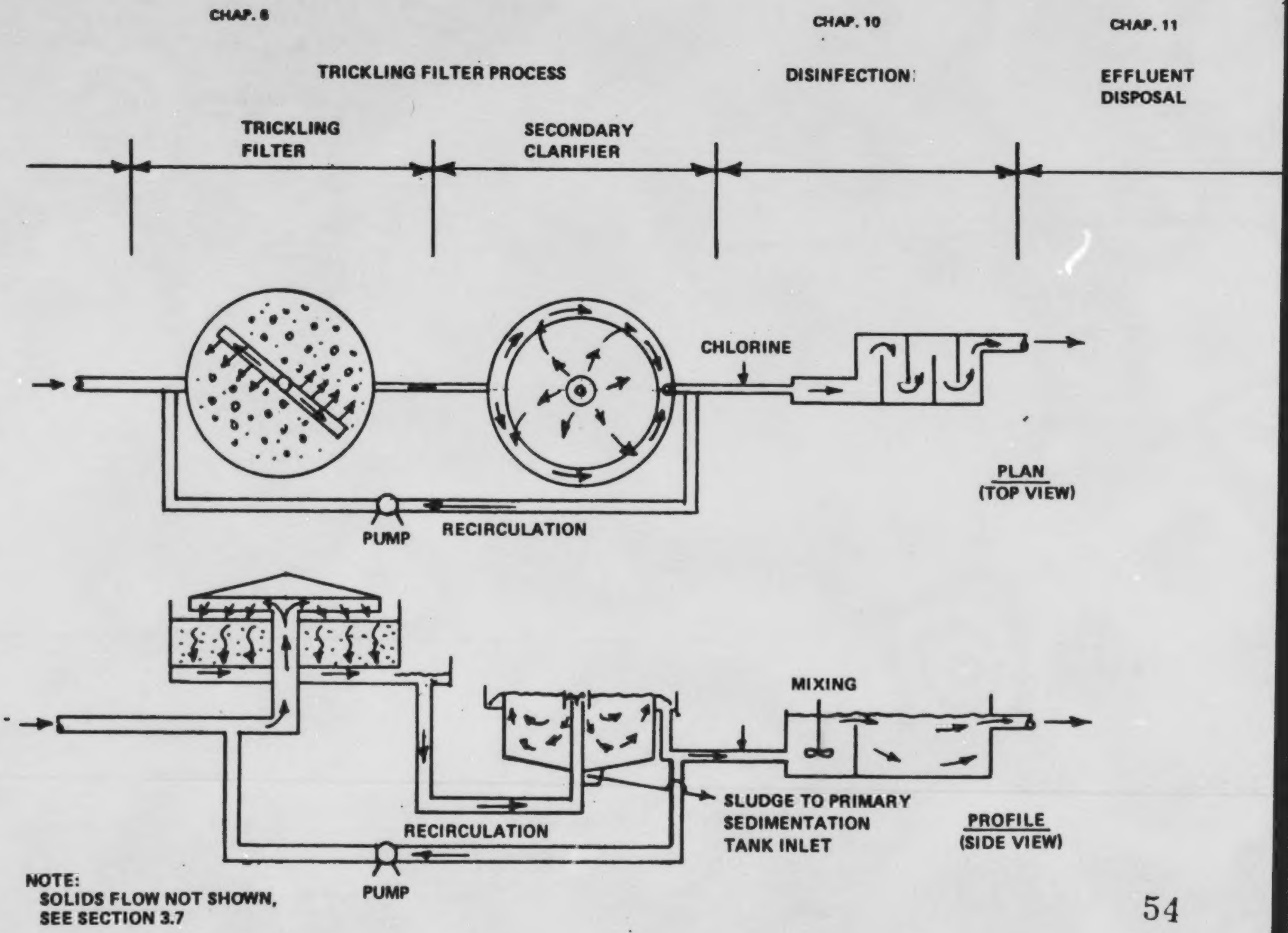
Fig. 4.b
26


CHAP. 4
CHAP. 11
CHAP. 4
CHAP. 11
CHAP. 5
PLANT INFLUENT FROM COLLECTION SYSTEM
BAR RACKS
FLOW METER, PARSHALL FLUME
COMMINUTOR
PUMP (IN WET WELL)
PRIMARY SEDIMENTATION TANK
PLAN (TOP VIEW)
SCUM TO DIGESTER OR TO BURIAL
SOLIDS TO BURIAL
PROFILE (SIDE VIEW)
SLUDGE TO DIGESTER

NOTE: SOLIDS FLOW NOT SHOWN, SEE SECTION 3.7

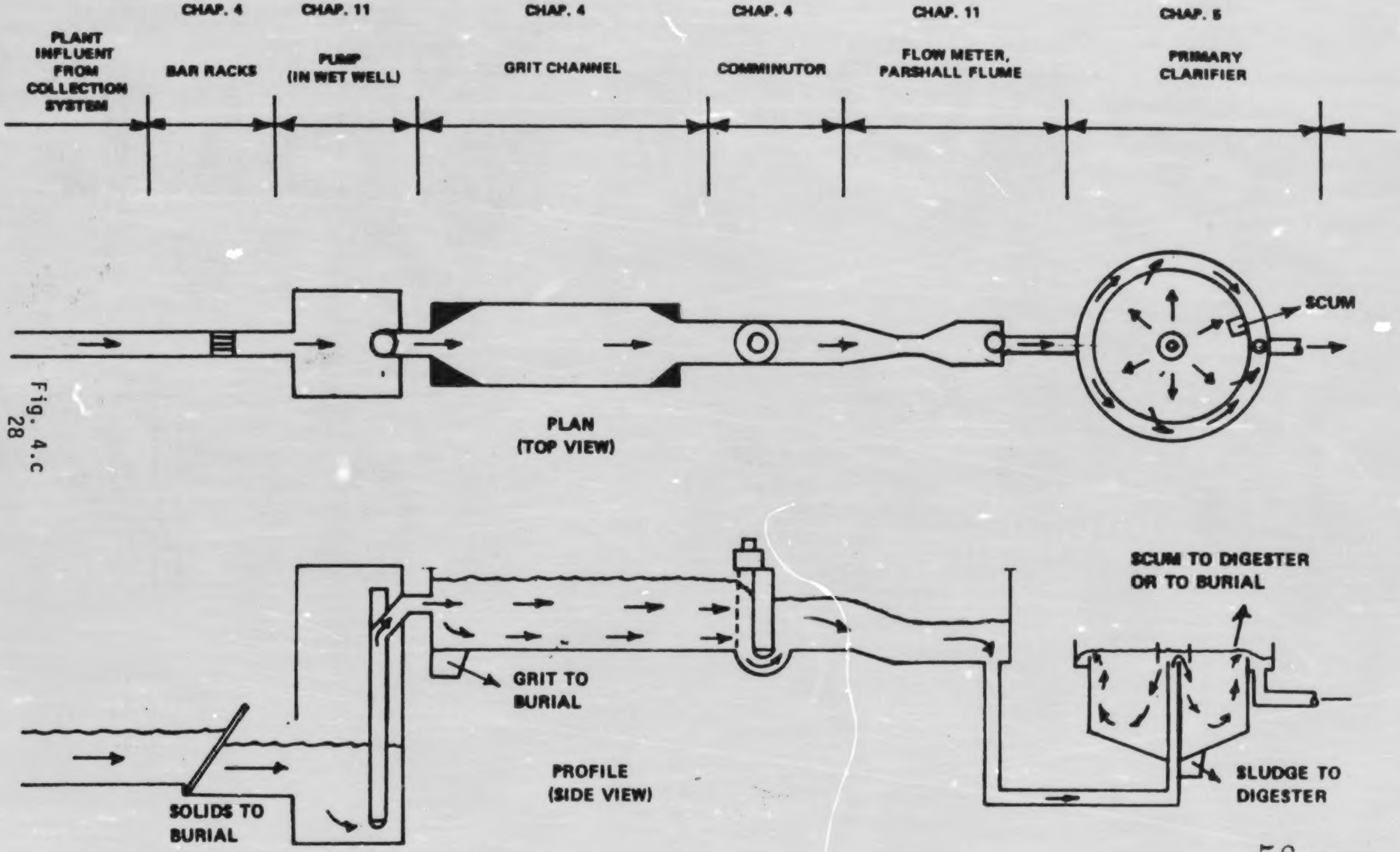
Possible flow pattern through a trickling filter plant

Fig. 4.b (Con'd)
27


CHAP. 6
CHAP. 10
CHAP. 11
TRICKLING FILTER PROCESS
DISINFECTION
EFFLUENT DISPOSAL
TRICKLING FILTER
SECONDARY CLARIFIER
CHLORINE
PLAN (TOP VIEW)
PUMP
RECIRCULATION
MIXING
SLUDGE TO PRIMARY SEDIMENTATION TANK INLET
PROFILE (SIDE VIEW)
RECIRCULATION
PUMP
NOTE:
SOLIDS FLOW NOT SHOWN,
SEE SECTION 3.7

(Con'd) Possible flow pattern through a trickling filter plant

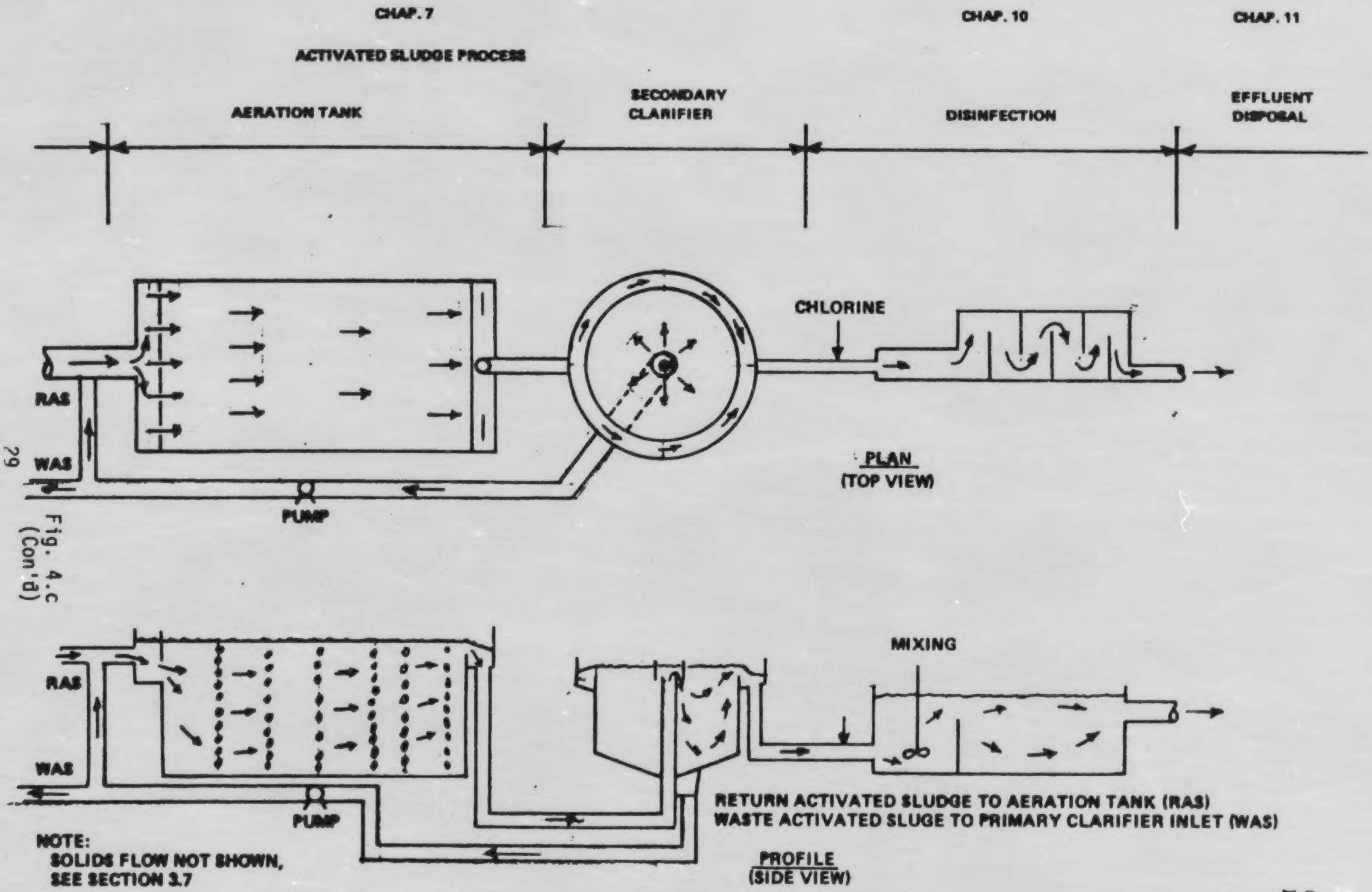
Fig. 4.c
28


CHAP. 4
CHAP. 11
CHAP. 4
CHAP. 4
CHAP. 11
CHAP. 5
PLANT INFLUENT FROM COLLECTION SYSTEM
BAR RACKS
PUMP (IN WET WELL)
GRIT CHANNEL
COMMINUTOR
FLOW METER, PARSHALL FLUME
PRIMARY CLARIFIER
SCUM
PLAN (TOP VIEW)
SCUM TO DIGESTER OR TO BURIAL
GRIT TO BURIAL
PROFILE (SIDE VIEW)
SLUDGE TO DIGESTER
SOLIDS TO BURIAL

NOTE: SOLIDS FLOW NOW SHOWN, SEE SECTION 3.7

Possible flow pattern through an activated sludge plant

Fig. 4.c
(Con'd)


CHAP. 7
ACTIVATED SLUDGE PROCESS
CHAP. 10
CHAP. 11
AERATION TANK
SECONDARY CLARIFIER
DISINFECTION
EFFLUENT DISPOSAL
CHLORINE
RAS
WAS
PUMP
PLAN
(TOP VIEW)
MIXING
RAS
WAS
PUMP
RETURN ACTIVATED SLUDGE TO AERATION TANK (RAS)
WASTE ACTIVATED SLUGE TO PRIMARY CLARIFIER INLET (WAS)
PROFILE
(SIDE VIEW)
NOTE:
SOLIDS FLOW NOT SHOWN,
SEE SECTION 3.7

(Con'd) Possible flow patterns through an activated sludge plant

Week 3 **Hour** 1 (Con'd) **Chapter:** 3
Wastewater Facilities

Lesson Outline

3.32 Shredding

1. Barminutor
2. Comminutor
3. Intended to shred or cut up material in wastewater to prevent damaging and/or plugging of pumps and pipes.

3.33 Grit Chambers or Grit Channels

1. Intended to remove heavy inorganic materials
2. Flow through velocity of 1 foot per second

Lecture Notes

Week 3 **Hour** 2 **Chapter:** 3
Wastewater Facilities

Lesson Outline	Lecture Notes
Objectives: 1. Identify flow measuring devices and primary and secondary treatment processes. 2. Describe purpose and how flow measuring devices and primary and secondary treatment processes work. Lecture Outline 3.4 Flow Measuring Devices 1. Flow measuring devices are not for treating wastes; however, you must know the quantity of wastewater flow so adjustments can be made on pumping rates, chlorination rates, aeration rates, and other processes in the plant. Flow rates must be known also, for calculation of loadings on treatment processes and treatment efficiency. 2. Parshall flumes 3. Weirs	

Week 3 **Hour** 2 (Con'd) **Chapter:** 3
Wastewater Facilities

Lesson Outline

4. Advantages of Parshall flumes over weirs
5. Magnetic flow meters
6. Other devices used in local plants

3.5 Primary Treatment

Refer to Fig.5, Rectangular clarifier and Fig. 6, Circular clarifier

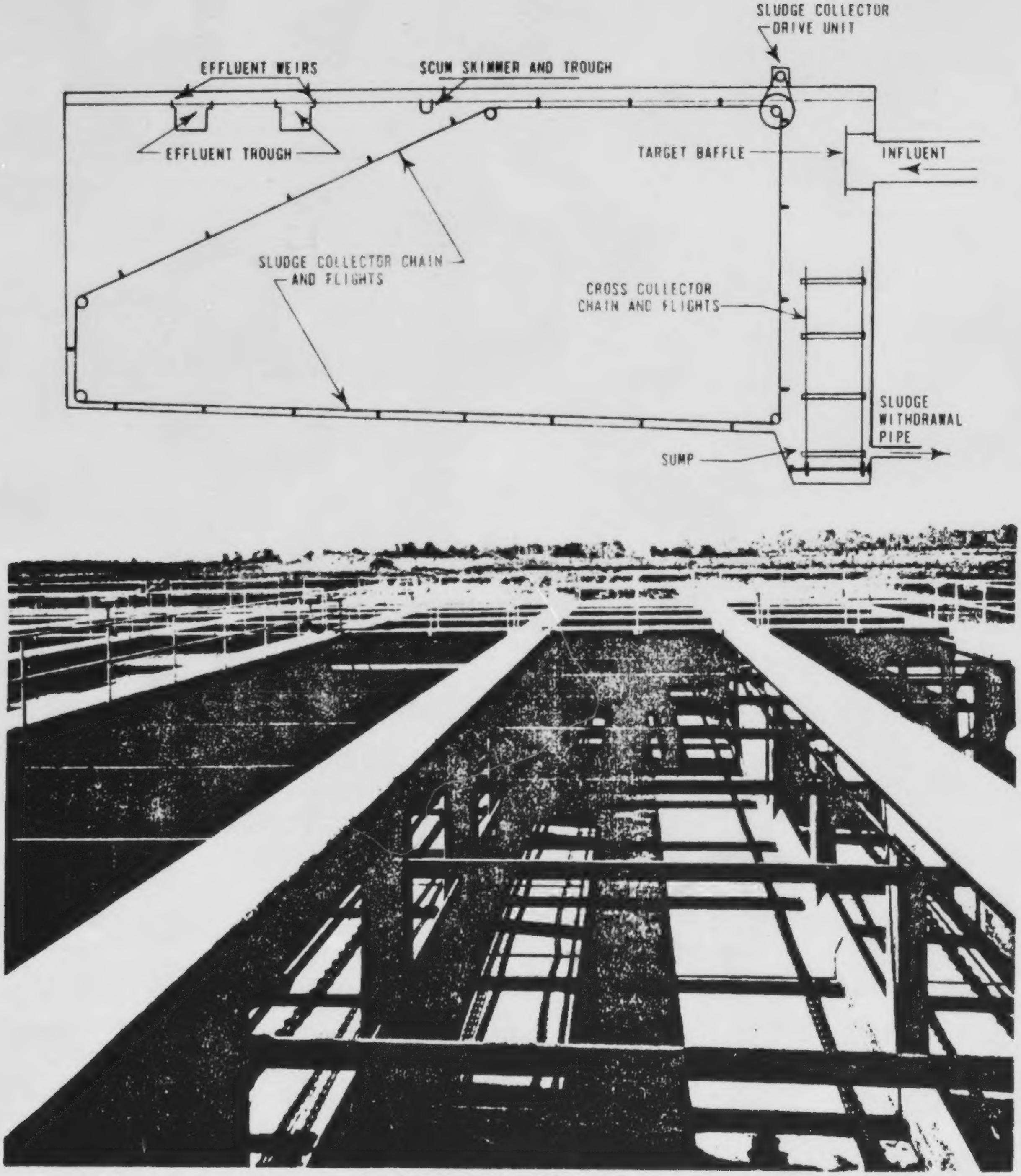
1. Rectangular or circular sedimentation tanks or clarifiers.
2. Removal of suspended solids and biochemical oxygen demand (BOD)
3. Define and explain meaning of BOD
4. Removal of sludge
5. Define and explain sludge
6. Removal of scum

3.6 Secondary Treatment

3.60 Purpose

Provide an environment for living organisms (such as bacteria) to eat the dissolved and non-settleable organic material remaining in the waste.

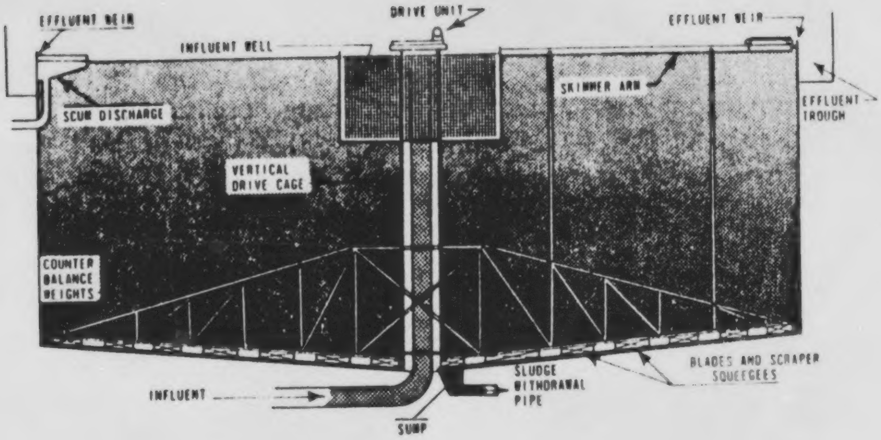
Lecture Notes

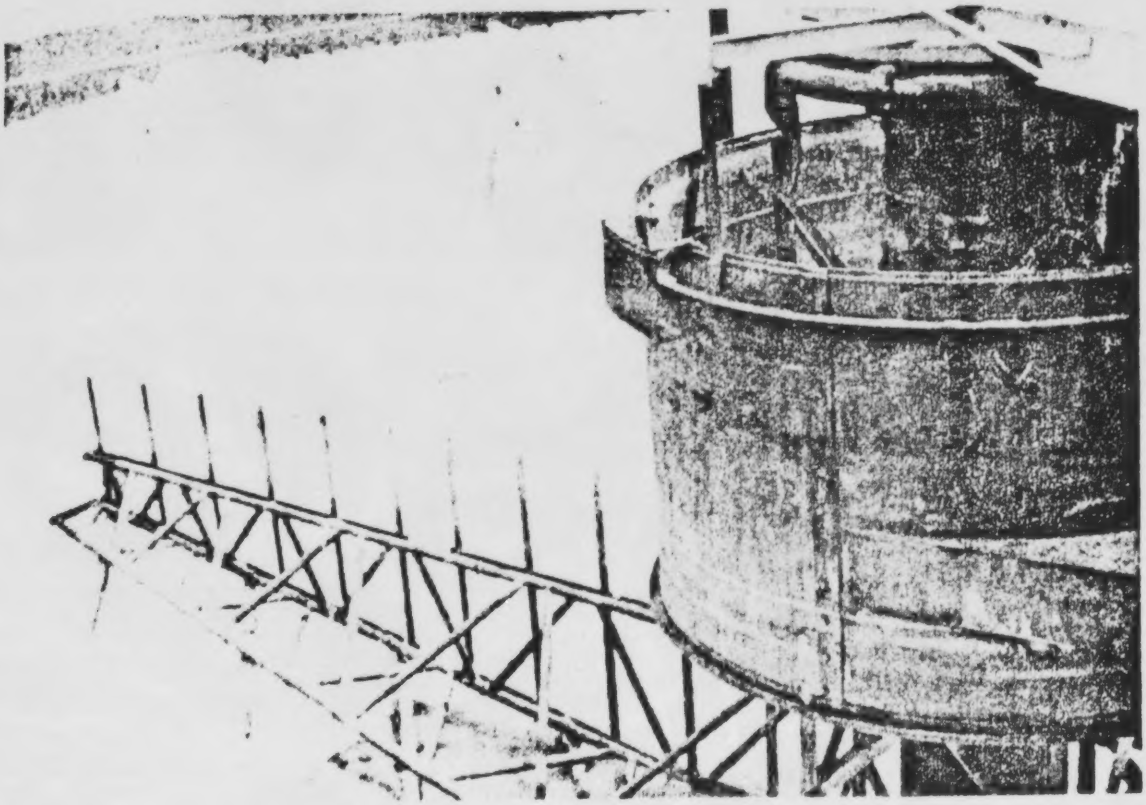

SLUDGE COLLECTOR DRIVE UNIT
EFFLUENT WEIRS
SCUM SKIMMER AND TROUGH
EFFLUENT TROUGH
TARGET BAFFLE
INFLUENT
SLUDGE COLLECTOR CHAIN AND FLIGHTS
CROSS COLLECTOR CHAIN AND FLIGHTS
SLUDGE WITHDRAWAL PIPE
SUMP

Rectangular clarifier

(Courtesy Jeffrey)

Fig. 5


EFFLUENT WEIR
DRIVE UNIT
EFFLUENT WEIR
INFLUENT WELL
SKIMMER ARM
SCUM DISCHARGE
EFFLUENT TROUGH
VERTICAL DRIVE CAGE
COUNTER BALANCE WEIGHTS
SLUDGE WITHDRAWAL PIPE
BLADES AND SCRAPER SQUEEGEES
INFLUENT
SUMP

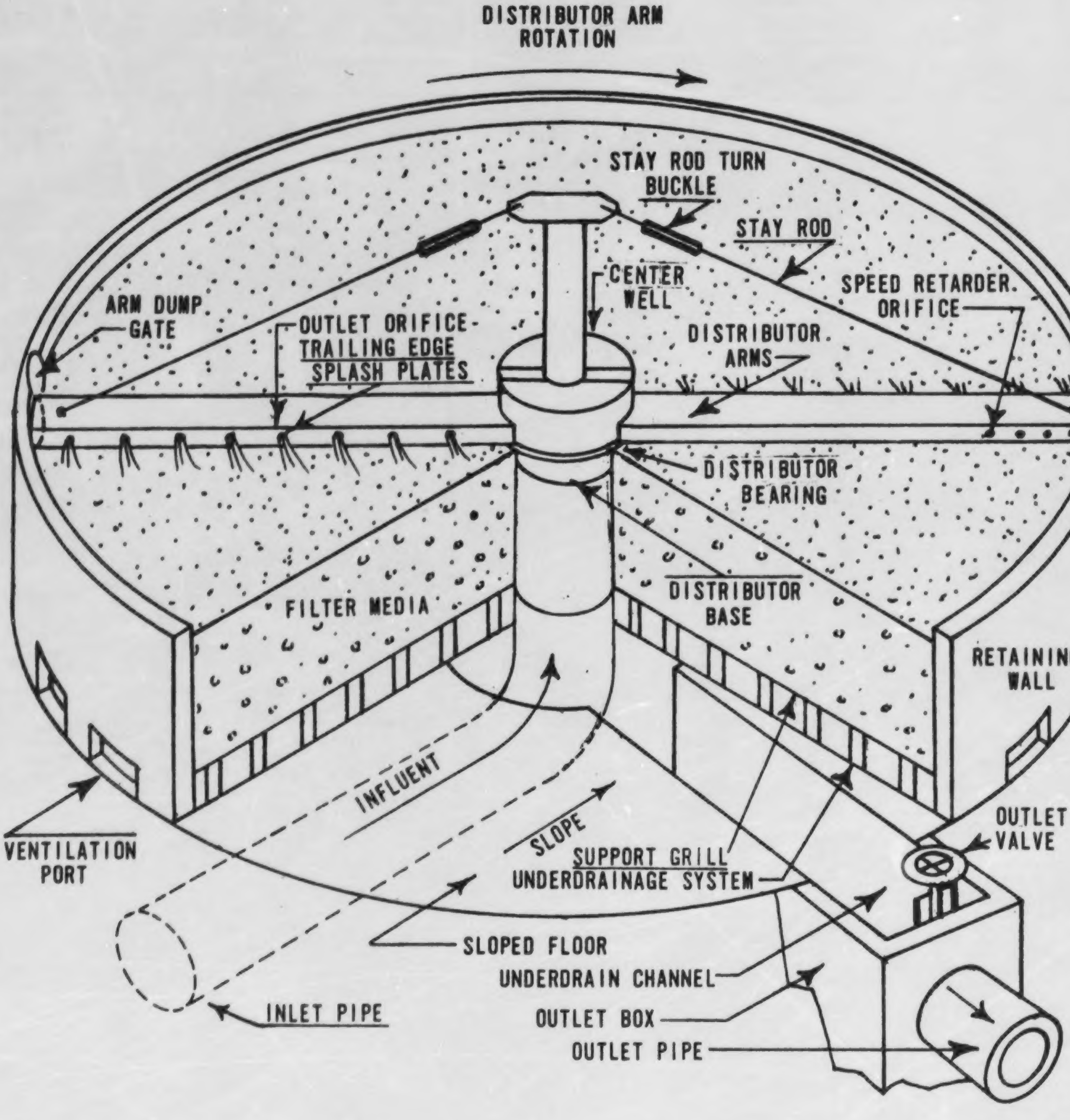


Circular clarifier

Fig. 6

Week 3 **Hour** 2 (Con'd) **Chapter:** 3
Wastewater Facilities

Lesson Outline	**Lecture Notes**
3.61 Describe trickling filter process (See Fig. 7) a. Application of wastewater b. Trickle over rocks or media c. Collection or underdrain system 3.62 Describe activated sludge process a. Entrance of wastewater to aeration tank b. Return activated sludge (RAS) c. Aeration devices d. Mixing of wastewater with return activated sludge e. How organisms treat waste 3.63 Secondary clarifiers a. Describe clarifier (similar to primary clarifiers) b. Purpose: To separate solids and organisms from water being treated and to produce a clear effluent. c. Sludge removal	


DISTRIBUTOR ARM ROTATION
STAY ROD TURN BUCKLE
STAY ROD
CENTER WELL
SPEED RETARDER ORIFICE
ARM DUMP GATE
OUTLET ORIFICE
TRAILING EDGE SPLASH PLATES
DISTRIBUTOR ARMS
DISTRIBUTOR BEARING
FILTER MEDIA
DISTRIBUTOR BASE
RETAINING WALL
INFLUENT
SLOPE
OUTLET VALVE
VENTILATION PORT
SUPPORT GRILL
UNDERDRAINAGE SYSTEM
SLOPED FLOOR
UNDERDRAIN CHANNEL
OUTLET BOX
INLET PIPE
OUTLET PIPE

Trickling filter

Fig. 7

Week 3 **Hour** 3 **Chapter:** 3
Wastewater Facilities

Lesson Outline

Objectives:

1. Identify solids handling and disposal processes, waste treatment ponds, and effluent disposal techniques.
2. Describe purpose of solids handling and disposal processes, waste treatment ponds, and effluent disposal techniques and how they work.

Lecture Outline

3.7 Solids Handling and Disposal

- 3.70 Purpose

  Digestion, decomposition and dewatering of sludge solids to a condition where they can be disposed of ultimately by burning (incineration) or burial in an approved sanitary landfill.

- 3.71 Digestion and dewatering
  1. Settled sludge removed from primary clarifier to digester.

Lecture Notes

Week 3 Hour 3 (Con'd) **Chapter:** 3
Wastewater Facilities

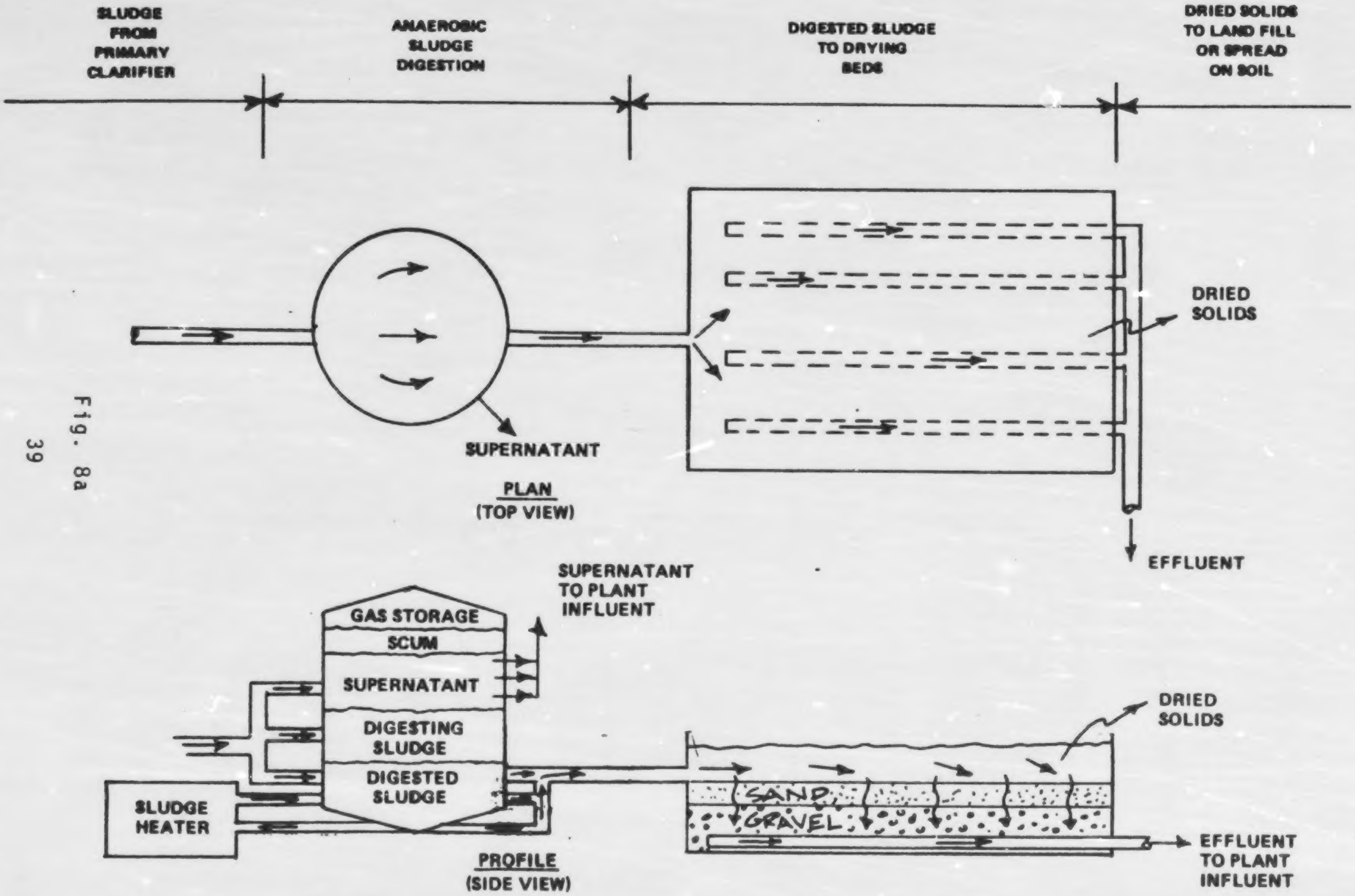
Lesson Outline

2. Aerobic digesters. An extension of the activated sludge process where sludge is aerated in an aeration tank.
3. Anaerobic digesters. (Refer to Figures 8a, 8b, and 9) An environment suitable for anaerobic bacteria to treat or digest the sludge. Acid forming bacteria eat or break down the organic portion of the sludge to form organic acids and carbon dioxide gas. A second group of bacteria called "gas formers" break down the organic acids to simpler compounds, and form methane and carbon dioxide gas.
4. Digester mixing
5. Separation of digested sludge and liquid (supernatant).

Lecture Notes

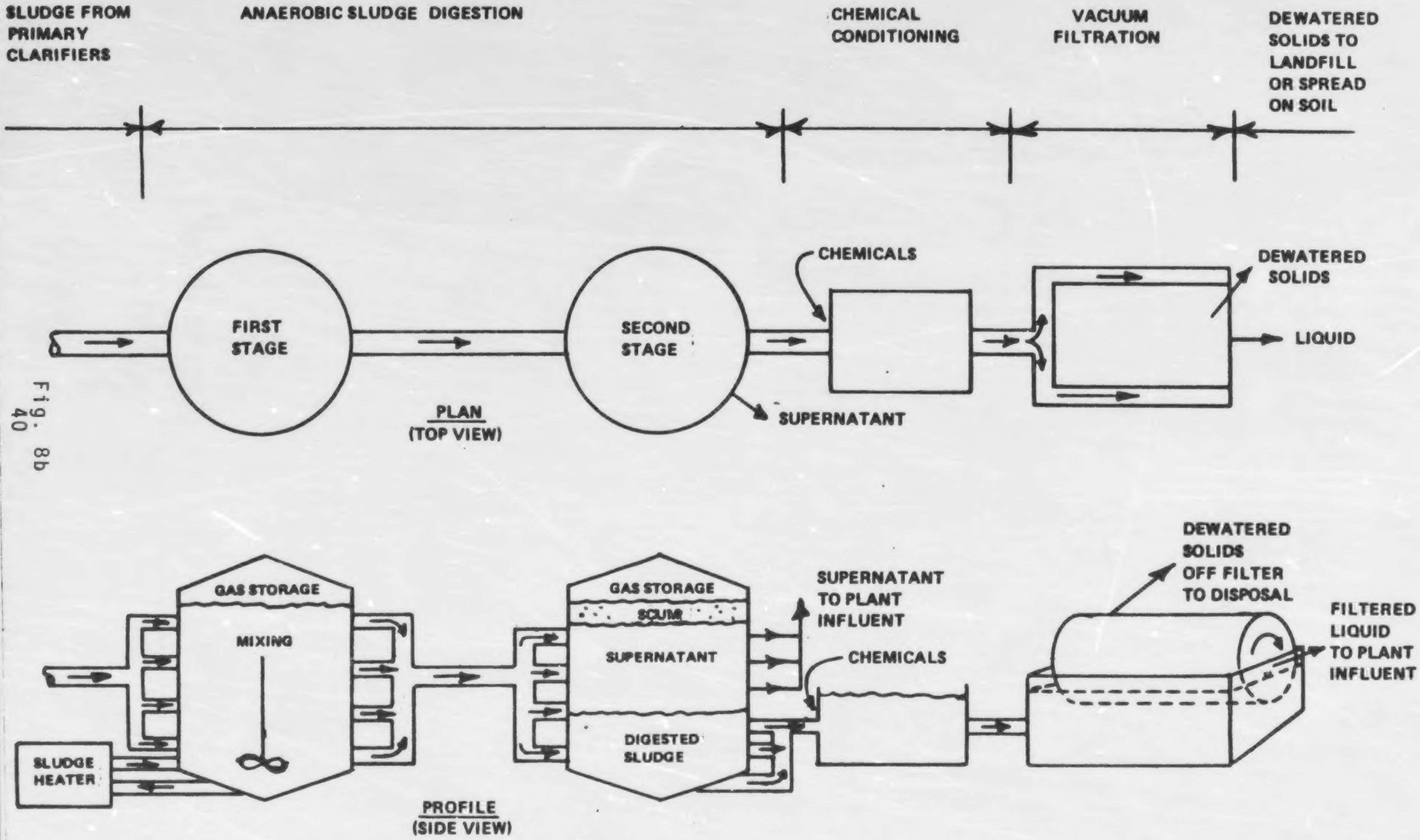
Fig. 8a

39


SLUDGE FROM PRIMARY CLARIFIER
ANAEROBIC SLUDGE DIGESTION
DIGESTED SLUDGE TO DRYING BEDS
DRIED SOLIDS TO LAND FILL OR SPREAD ON SOIL
DRIED SOLIDS
SUPERNATANT
PLAN
(TOP VIEW)
EFFLUENT
SUPERNATANT TO PLANT INFLUENT
GAS STORAGE
SCUM
SUPERNATANT
DIGESTING SLUDGE
DIGESTED SLUDGE
SLUDGE HEATER
DRIED SOLIDS
SAND
GRAVEL
EFFLUENT TO PLANT INFLUENT
PROFILE
(SIDE VIEW)

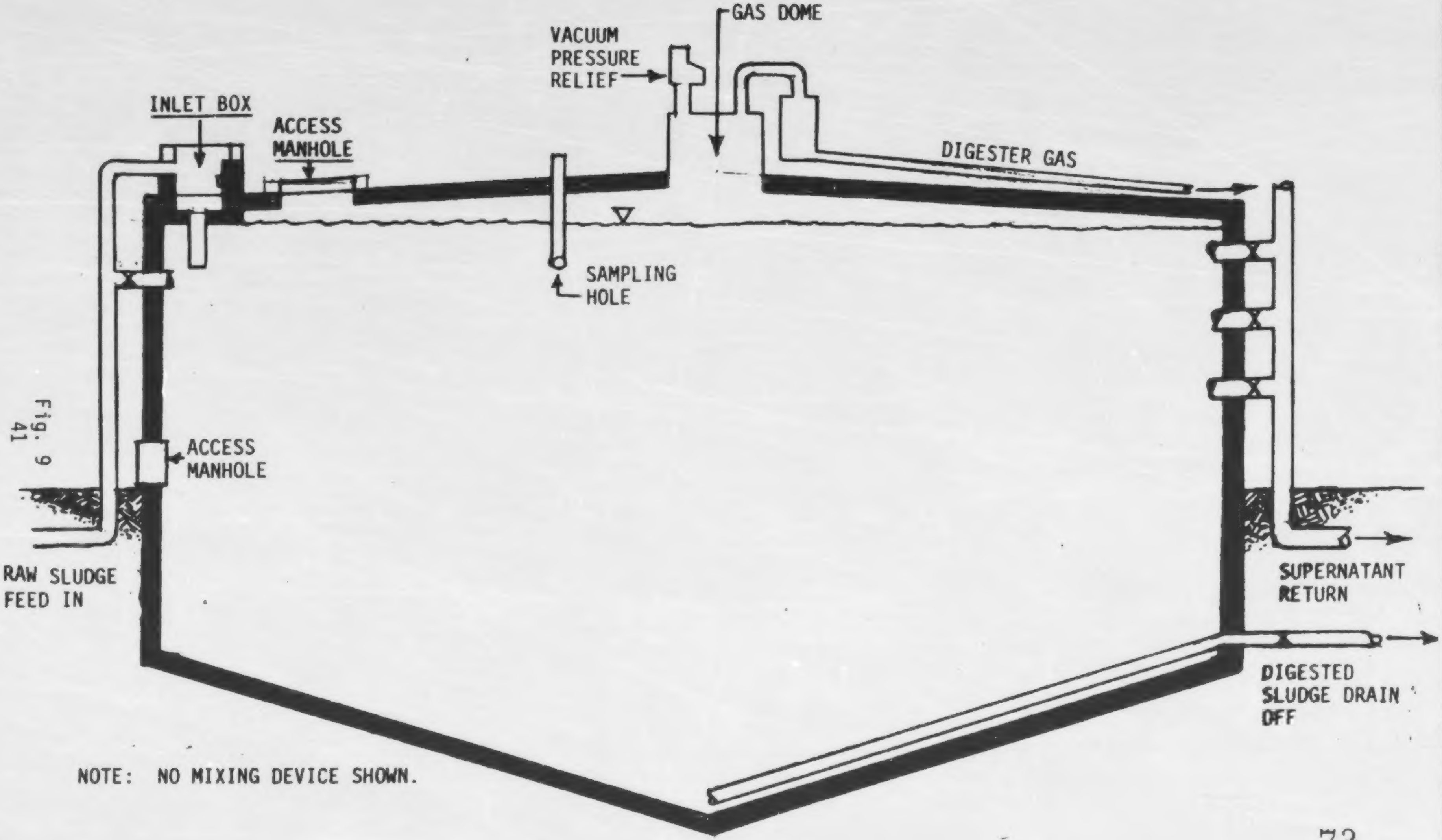
Possible sludge processing and solids disposal flow pattern
(sludge drying beds)

Fig. 8b
40


SLUDGE FROM PRIMARY CLARIFIERS
ANAEROBIC SLUDGE DIGESTION
CHEMICAL CONDITIONING
VACUUM FILTRATION
DEWATERED SOLIDS TO LANDFILL OR SPREAD ON SOIL
FIRST STAGE
SECOND STAGE
CHEMICALS
DEWATERED SOLIDS
LIQUID
SUPERNATANT
PLAN
(TOP VIEW)
GAS STORAGE
MIXING
SLUDGE HEATER
GAS STORAGE
SCUM
SUPERNATANT
DIGESTED SLUDGE
SUPERNATANT TO PLANT INFLUENT
CHEMICALS
DEWATERED SOLIDS OFF FILTER TO DISPOSAL
FILTERED LIQUID TO PLANT INFLUENT
PROFILE
(SIDE VIEW)

Possible sludge processing and solids disposal flow pattern
(vacuum filtration)

Fig. 9
41


GAS DOME
VACUUM PRESSURE RELIEF
INLET BOX
ACCESS MANHOLE
DIGESTER GAS
SAMPLING HOLE
ACCESS MANHOLE
RAW SLUDGE FEED IN
SUPERNATANT RETURN
DIGESTED SLUDGE DRAIN OFF

NOTE: NO MIXING DEVICE SHOWN.

Section of sludge digester

Lesson Outline	**Lecture Notes**
NOTE: In many anaerobic digesters the liquid will not separate from the digested sludge even after two days of no mixing. If this happens, there will be no supernatant. 6. Scum blanket 7. Digester gas a. Fuel value for heating sludge and other uses b. Explosive potential 8. Sludge dewatering Sand drying beds, lagoons, centrifuges, and vacuum filters. 9. Ultimate disposal Burning (incineration), burial in an approved sanitary landfill, possibility of use as a fertilizer or soil conditioner if hazards from viruses and toxic substances can be avoided.	

Week 3 **Hour** 3 (Con'd) **Chapter:** 3
Wastewater Facilities

Lesson Outline

3.8 Waste Treatment Ponds
  1. Describe ponds
  2. Purpose of ponds
  3. How ponds treat wastewater

3.9 Advanced Methods of Treating Wastewater
  1. Purpose: To remove specific waste constituents from the effluent from secondary biological treatment processes.
  2. Advance methods of waste treatment include coagulation - sedimentation (used in water treatment plants), microscreening, phosphorus removal, and nitrification (conversion of ammonium, NH_4^+, to nitrate, NO_3^-).

3.10 Disinfection
  1. Purpose: Killing of pathogenic (disease causing) bacteria.
  2. Disinfection commonly accomplished by the application of chlorine to the plant's effluent (chlorination).
  3. Use of chlorine gas and hypochlorite solution.

Lecture Notes

Week 3 **Hour** 3 (Con'd) **Chapter:** 3
Wastewater Facilities

Lesson Outline

4. Chlorine contact basins
5. Dechlorination
    a. Purpose: To dechlorinate effluent so it won't be toxic to aquatic organisms.
    b. Method: Use of sulfur dioxide (SO_2) gas (Sulfonation) Sulfonators are similar to chlorinators.
6. Odor control by chlorination.

3.11 Effluent Disposal

1. Dilution
2. Land disposal
3. Recharging ground water
4. Wastewater reclamation
    a. Industrial reuse
    b. Parks and landscaping
    c. Future demands

3.12 Solids Disposal

Lecture Notes

Week 3 **3- Hour** Lab (Optional) **Chapter:** 3 Wastewater Facilities

Lesson Outline	Lecture Notes
Objective: Visit a water treatment plant or an advanced wastewater treatment plant to familiarize yourself with this type of treatment plant. Assignment: 1. Describe the purpose of each treatment process and how it works. 2. Prepare a list of tasks done by the operators. OR Objective: Tour a wastewater collection system to become familiar with the sources of wastewater. Assignment: 1. List the sources of wastewater and the characteristics of the wastewater from the major sources. 2. Prepare a list of sewer maintenance activities that could adversely influence wastewater characteristics and flows into a wastewater treatment plant.	

CHAPTER 4

RACKS, SCREENS, COMMINUTORS AND GRIT REMOVAL

Week 4 Hour 1 Chapter: 4
Racks, Screens, Comminutors and Grit Removal

Lesson Outline

Objectives: Refer to objectives listed at the beginning of Chapter 4, Racks, Screens Comminutors and Grit Removal.

Assignment: Objective test and discussion and review questions at end of Chapter 4.

Lecture Outline

Glossary: Review new words

4.0 Caution

1. Think Safety
2. Follow safe procedures
3. Good personal hygiene must be observed at all times. Always wash your hands thoroughly before eating or smoking!
4. Beware of slow moving equipment

4.1 Pretreatment

Refer to Fig. 10, Flow diagram of a typical plant

1. Material and wastes found in plant influent.
2. Purpose: To remove sand, eggshells, and similar materials (grit) that can plug pipes, cause excessive wear in pumps, and use up valuable

Lecture Notes

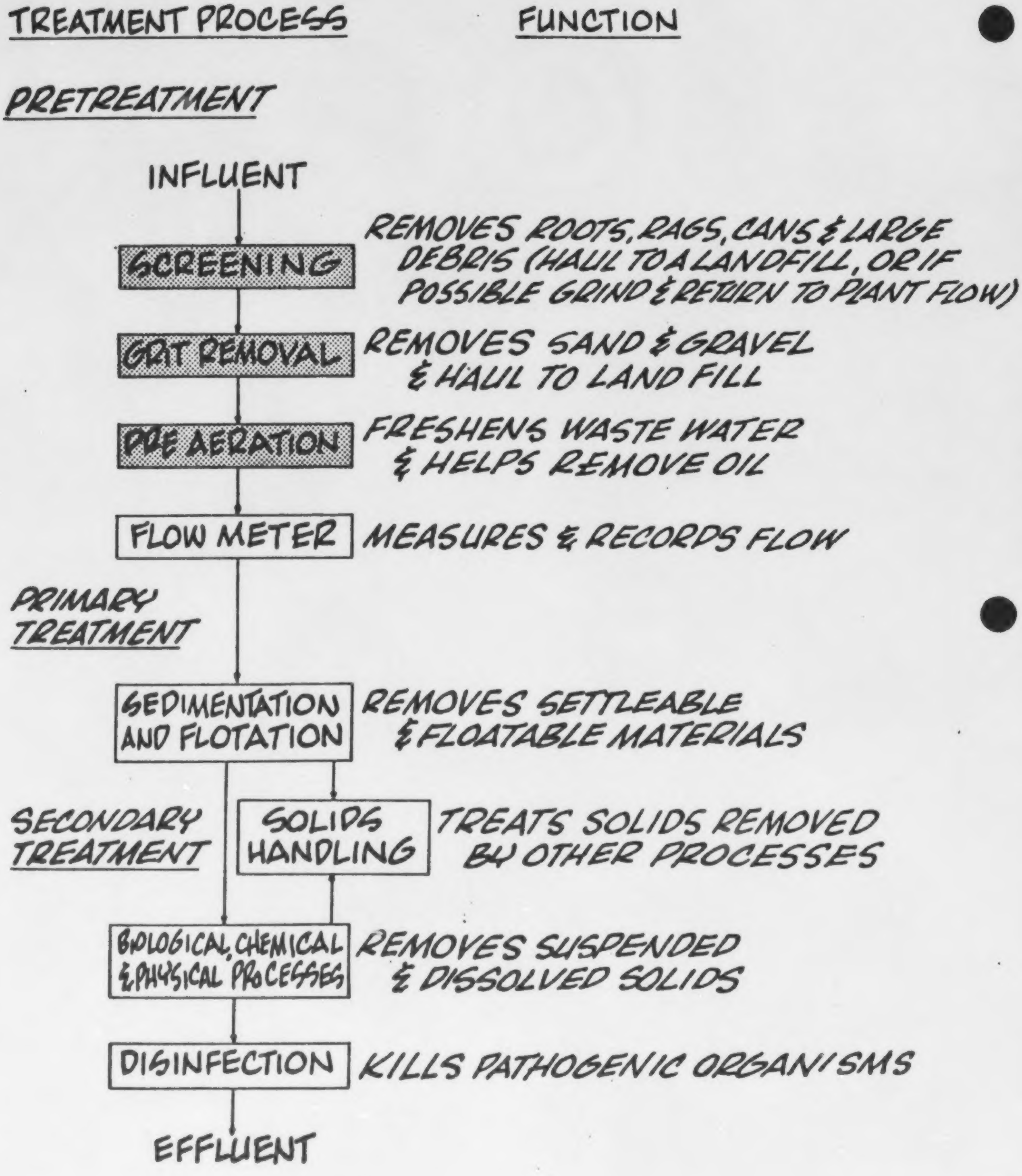

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 10

Lesson Outline	Lecture Notes
space in sludge digesters. Also, grit is very difficult to remove from digesters. 3. Problems caused by plugged pipes, jammed collector mechanisms or malfunctioning pumps. 4. Screening 5. Grit Removal 6. Preaeration 4.2 Bar Screens and Racks 1. Describe bar screens and racks 2. Purpose: To remove heavy coarse materials 3. Mechanical cleaning method 4.20 Safety around bar screens and racks 1. Slipping and falling 2. Drowning 3. Disease 4. Back injuries and muscle strain 5. When working on mechanical equipment, tag controls,	

Week 4 **Hour** 1 (Con'd) **Chapter:** 4
Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes
lock power off and take the key with you! 4.21 Manually cleaned bar screens 1. Purpose and components of manually cleaned bar screens (See Table 4.1, Second Edition). 2. What happens if too much debris collects on bars and wastewater backs up in sewer? 4.22 Mechanically cleaned screens 1. Describe equipment 2. Beware of slow moving equipment 3. Trouble-shooting. Rake will not move. a. Rake mechanism jammed; or b. Equipment broken 4.23 Operational Procedures 1. Routine operation 2. Abnormal operation resulting from storms or sewer cleaning operations by maintenance crews.	

Week 4 Hour 1 (Con'd) Chapter: 4
Racks, Screens, Comminutors and
Grit Removal

Lesson Outline	Lecture Notes
3. Removal from operation or shut down 4.3 Disposal of Screenings 1. Reasons for disposal. 2. Methods of disposal (burial, incineration, and shredding or grinding). 3. Problems caused by use of shredders and grinders. 4. Calculation of volume or filling rate for screenings in a sanitary landfill operation. 5. Calculation of volume or capacity of disposal pit. 6. Calculation of days or time to fill disposal pit.	

Week 4 Hour 2 Chapter: 4
Racks, Screens, Comminutors and Grit Removal

Lesson Outline

Lecture Notes

Objectives: Refer to objectives listed at the beginning of Chapter 4, Racks, Screens Comminutors and Grit Removal.

Lecture Outline

4.4 Comminution

  4.40 Comminutors

  1. Description of comminutor
  2. Purpose and components of comminutors (Table 4.2, Second Edition)
  3. Maintenance
  4. Safety. Never attempt to unplug or unjam the cutter blades without FIRST by-passing the unit and then turning off the electrical power, locking out switches and placing tags on the switches indicating who did it and when. Keep the key in your pocket.

  4.41 Barminutors

  1. Describe barminutor

Lesson Outline	Lecture Notes
2. Purpose of barminutor components (Table 4.3, Second Edition) 3. Maintenance 4. Safety 4.42 Operational Procedures 1. Routine operation 2. Abnormal operation resulting from sudden high flows or heavy amounts of debris (from industrial dumps, sewer lines maintenance on storm flows) 3. Start up and shut down 4.5 Grit Removal 1. Grit (sand, eggshells, and cinders) is the heavier mineral matter in wastewater that will not decompose or "break down". 2. Grit causes excessive wear in pumps. 3. Grit, tar and grease can form a solid mass in pipes and digesters that will not move and cannot be removed by ordinary means.	

Week 4	**Hour** 2 (Con'd)	**Chapter:** 4 Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes
4. Grit should be removed as soon as possible after it reaches a treatment plant.	
4.6 Grit Channels	
1. Velocity, 0.7 to 1.4 ft/sec (0.2 to 0.4 m/sec)	
2. Objective: To allow grit to settle to the bottom of the grit channel while keeping the lighter organic solids moving along to the next treatment unit.	
3. Control of velocity in grit channel	
4. Purpose of grit channels and components (Table 4.4, Second Edition)	
5. Calculation of velocity in grit channel. $\text{Velocity, ft/sec} = \frac{\text{Distance, ft}}{\text{Time, sec}}$ OR $\text{Velocity, ft/sec} = \frac{\text{Flow, cu ft/sec}}{\text{Area, sq ft}}$	
6. Causes of dead spots and corrective action	
7. Frequency of cleaning and methods of cleaning	

Week 4 Hour 2 (Con'd) Chapter: 4
Racks, Screens, Comminutors and
Grit Removal

Lesson Outline	Lecture Notes
8. Safety a. Take precautions against slipping and back strain b. Beware of dangerous gases and lack of oxygen when working in covered grit channels 9. Start up 10. Normal operation 11. Abnormal operation 12. Shut down 13. Maintenance Aerated Grit Chambers 1. Description 2. Purpose of aerated grit chamber and components 3. Start up 4. Normal operation 5. Abnormal operation 6. Shut down	

Week 4 **Hour** 3 **Chapter:** 4
Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes

Objectives: Refer to objectives listed at the beginning of Chapter 4, Racks, Screens, Comminutors and Grit Removal.

Lecture Outline

4.7 Cyclone Grit Separators
    1. Describe cyclone grit separator
    2. Purpose of cyclone grit separator and components (Table 4.6, Second Edition)
    4.70 Safety
    4.71 Start Up
    4.72 Operation
        1. Feed
        2. Underflow discharge
        3. Feed inlet pressure and overflow discharge
    4.73 Shut down
    4.74 Maintenance
4.8 Grit Washing
    1. Purpose: To remove undersirable organic matter that settles with the grit.
    2. Purpose of grit washer and components (Table 4.7, Second Edition)

Week 4 **Hour** 3 (Con'd) **Chapter:** 4
Racks, Screens, Comminutors and Grit Removal

Lesson Outline

3. Start up
4. Normal operation
5. Shut down
6. Maintenance

4.9 Quantities of Grit

1. For separate sanitary collection systems, average 1 to 4 cu.ft. of grit per million gallons of flow.
2. For combined wastewater collection systems, 4 to 15 cu. ft. of grit per million gallons.

4.10 Disposal of Grit

Final disposal of grit is by burial with at least 6 inches of soil placed over the grit to keep out rats and flies.

4.11 Preaeration

1. Purpose: To help grit removal, freshen wastewater (remove gases and add oxygen), promote flotation of grease, and aid coagulation.
2. Describe process and equipment

Lecture Notes

Week 4 **Hour** 3 (Con'd) **Chapter:** 4
Racks, Screens, Comminutors and Grit Removal

Lesson Outline

Lecture Notes

4.12 Operational Strategy

1. Review normal operation
2. Decide how to respond to hydraulic and solids overloads
3. Prepare a plan for when sticks, rags and debris foul, plug or break equipment
4. Determine how downstream processes will have to be adjusted if pretreatment processes must be bypassed.

4.13 Design Review

Purpose: To allow operators the opportunity to suggest how treatment plants can be made easier to operate and maintain before they are constructed.

4.130 Racks and Screens

4.131 Grit Removal

4.132 Wet Wells

Week 4 3 -**Hour** Lab (Optional) **Chapter:** 4
Racks, Screens, Comminutors and Grit Removal

Lesson Outline

Objectives: Visit a wastewater treatment plant and observe or help (if possible) the operator operate and maintain the following pretreatment equipment and processes:

1. Bar screens and racks
2. Comminutors and/or barminutors
3. Grit channels
4. Grit separators
5. Grit washers
6. Preaeration

Lecture Notes

Week 5	**Hour** 1	**Chapters:** 1 through 4

Lesson Outline	Lecture Notes
Objective: Review for Exam I. 1. Cover important material in Chapters 1 through 4. 2. Emphasize purpose of processes, equipment and components. 3. Discuss start up, normal and abnormal operation, and shut down of processes and equipment. 4. Outline maintenance procedures. 5. Review safety hazards and safe procedures. 6. Identify important items that should be considered when reviewing plans and specifications. 7. Outline trouble-shooting procedures.	

Week 5   Hour 2   Chapters: 1 through 4

Lesson Outline	Lecture Notes
Objective: Exam I.	

Week 5 Hour 3 Chapters: 1 through 4

Lesson Outline	Lecture Notes
Objectives: 1. Review results of Exam I and correct all mistakes or errors. 2. Identify areas for future review and students who need additional help. NOTE: 1. If Exam I is not graded, continue on to Week 6, Hour 1, and review exam when available. 2. Some instructors may wish to schedule exams less frequently or more frequently and should feel free to do so.	

Week 5 3 - Hour Lab Chapter:
(Optional)

Lesson Outline	Lecture Notes
Suggest instructor select activity most suited to needs of students. 1. Perform maintenance or repair of a pump. OR 2. Draw diagrams of different types of plants.	

CHAPTER 5

SEDIMENTATION AND FLOTATION

Week 6 Hour 1 Chapter: 5
Sedimentation and Flotation

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at beginning of Chapter 5, Sedimentation and Flotation. Assignment: Discussion and review questions at the end of Lessons 1, 2, and 3 and objective test at end of Chapter 5. Lecture Outline Glossary: Review new words 5.0 Purpose of Sedimentation and Flotation. Refer to diagrams of a typical plant, Figures 11, 12, 13 and 14. NOTE: Primary treatment plants (Fig. 12) are no longer built today. Most primary plants are being or have been converted to secondary treatment plants by the addition of the trickling filter or activated sludge process. 1. Sedimentation tanks or clarifiers provide an opportunity for material in wastewater to either settle to the bottom or float to the surface for removal from the water being treated. Sedimentation and flotation occur when wastewater	

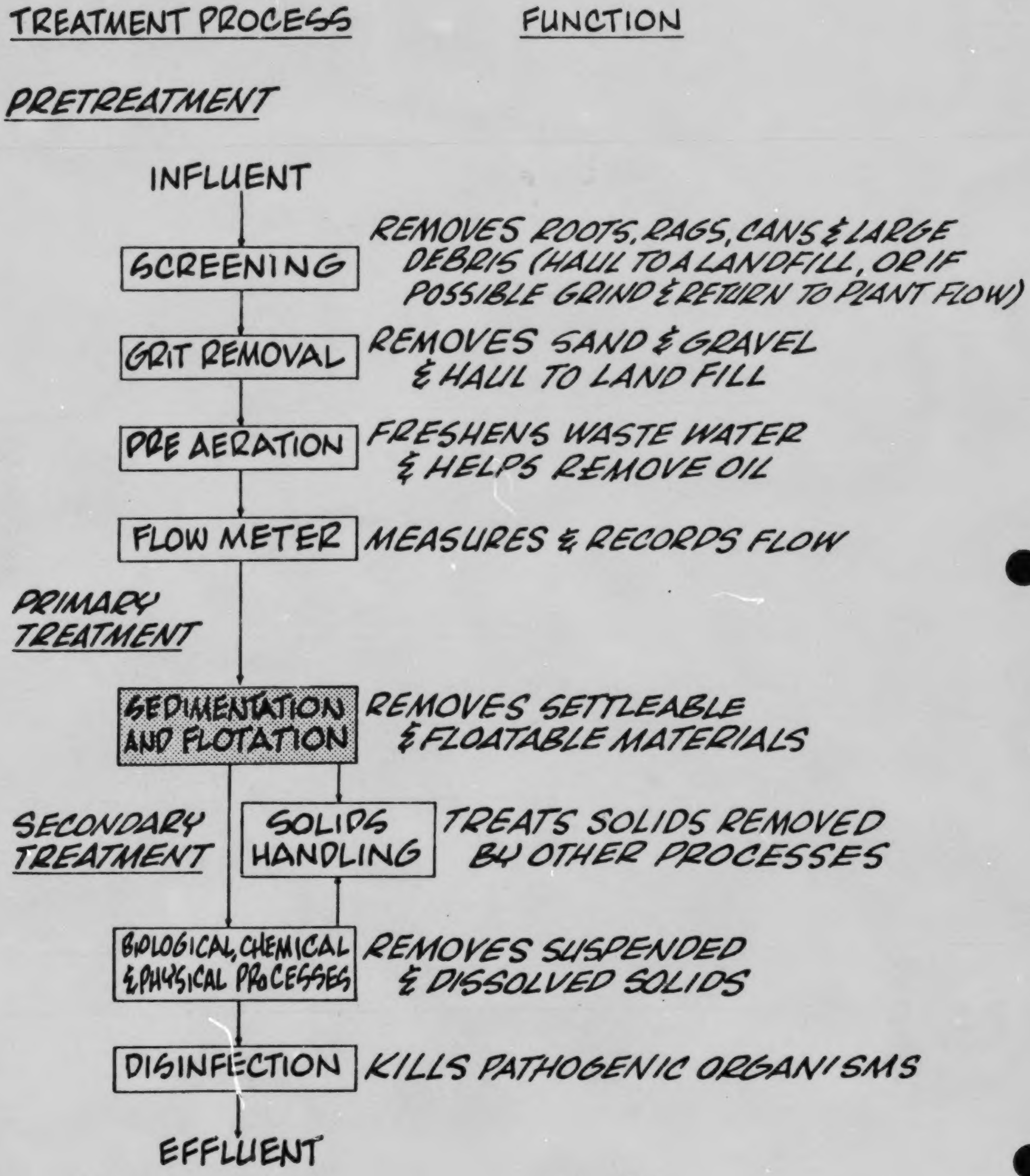
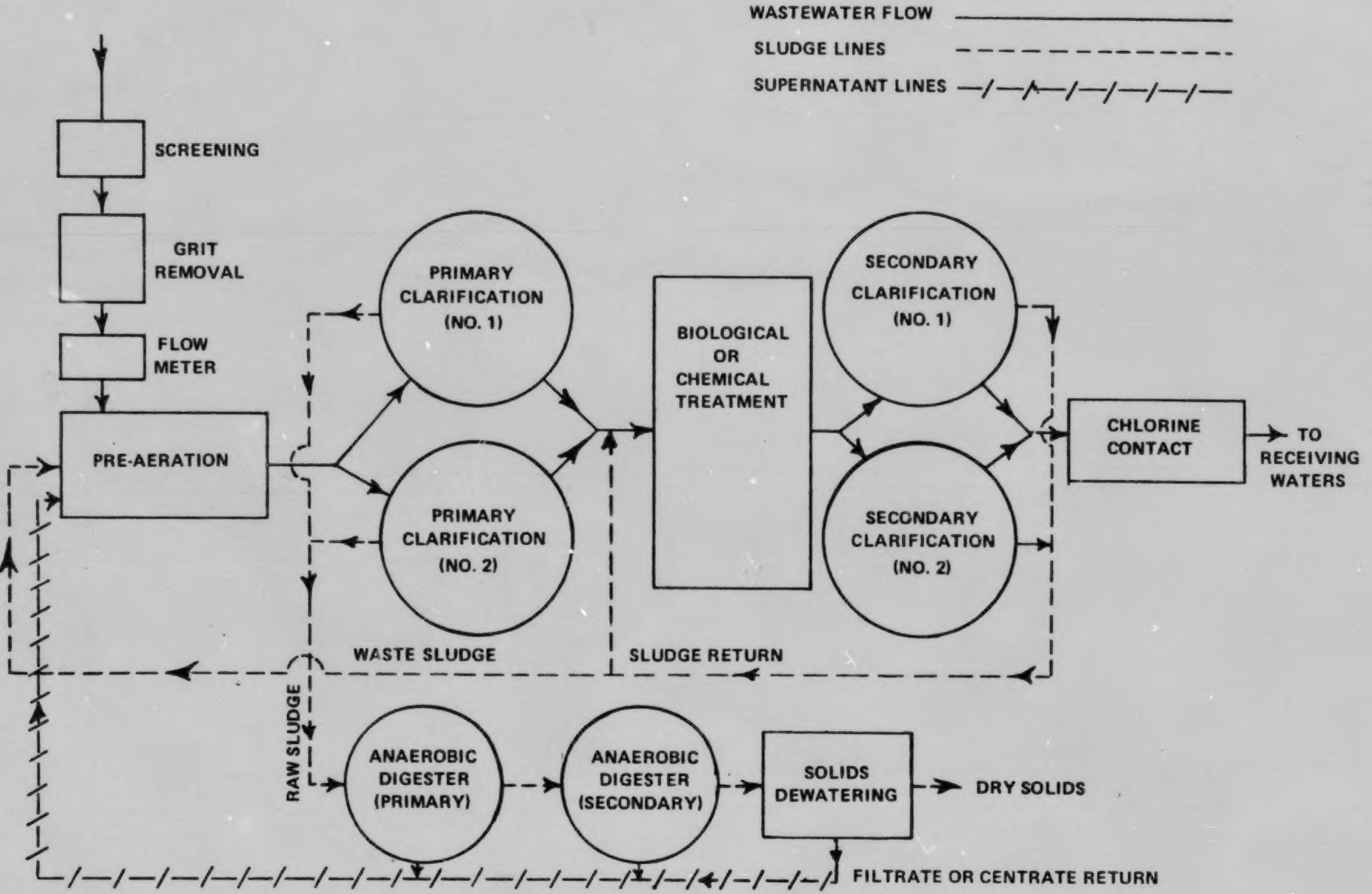

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

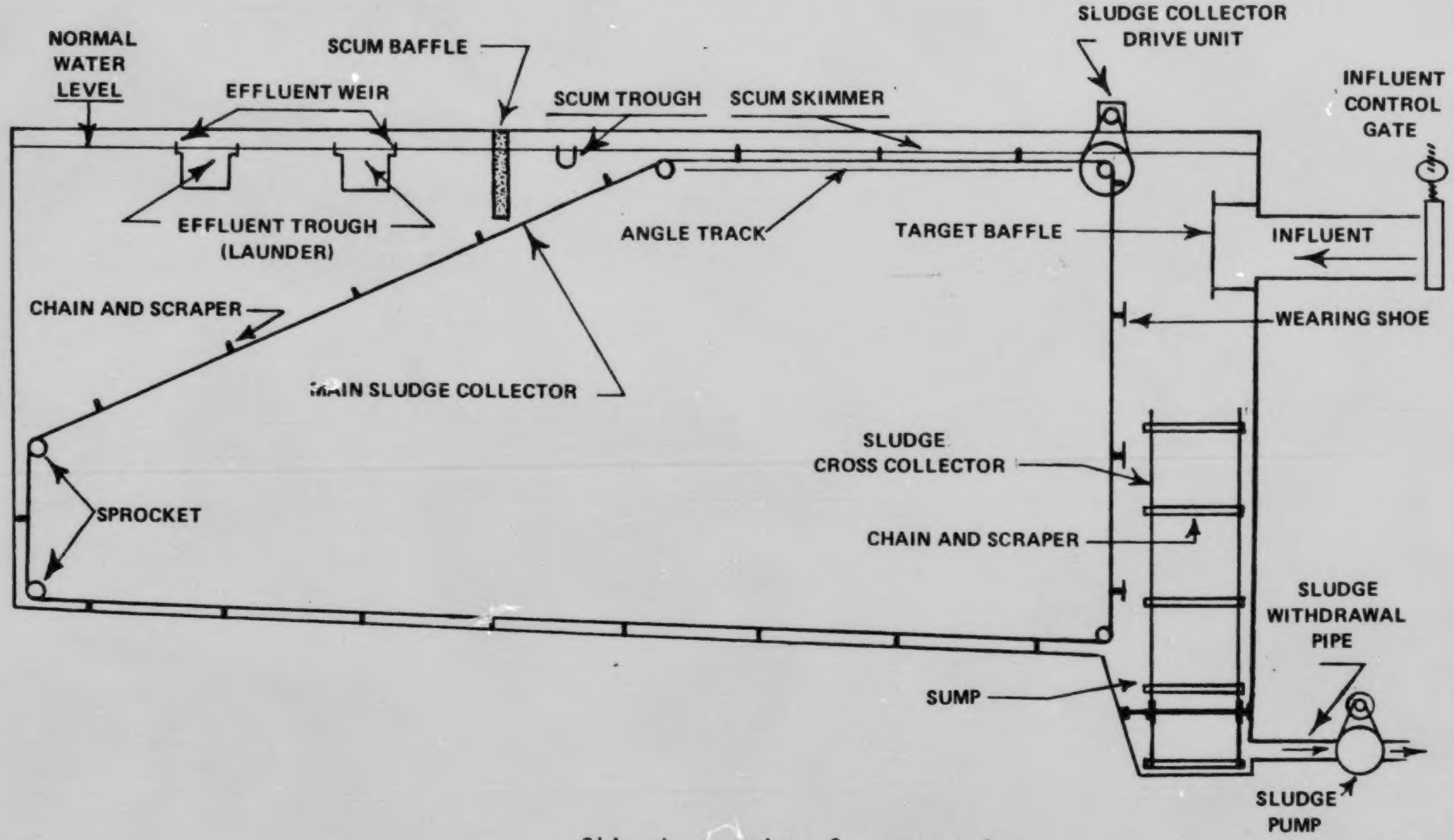
Fig. 11

Fig. 12
65


WASTEWATER FLOW
SLUDGE LINES
SUPERNATANT LINES
SCREENING
GRIT REMOVAL
FLOW METER
PRE-AERATION
PRIMARY CLARIFICATION (NO. 1)
PRIMARY CLARIFICATION (NO. 2)
BIOLOGICAL OR CHEMICAL TREATMENT
SECONDARY CLARIFICATION (NO. 1)
SECONDARY CLARIFICATION (NO. 2)
CHLORINE CONTACT
TO RECEIVING WATERS
WASTE SLUDGE
SLUDGE RETURN
RAW SLUDGE
ANAEROBIC DIGESTER (PRIMARY)
ANAEROBIC DIGESTER (SECONDARY)
SOLIDS DEWATERING
DRY SOLIDS
FILTRATE OR CENTRATE RETURN

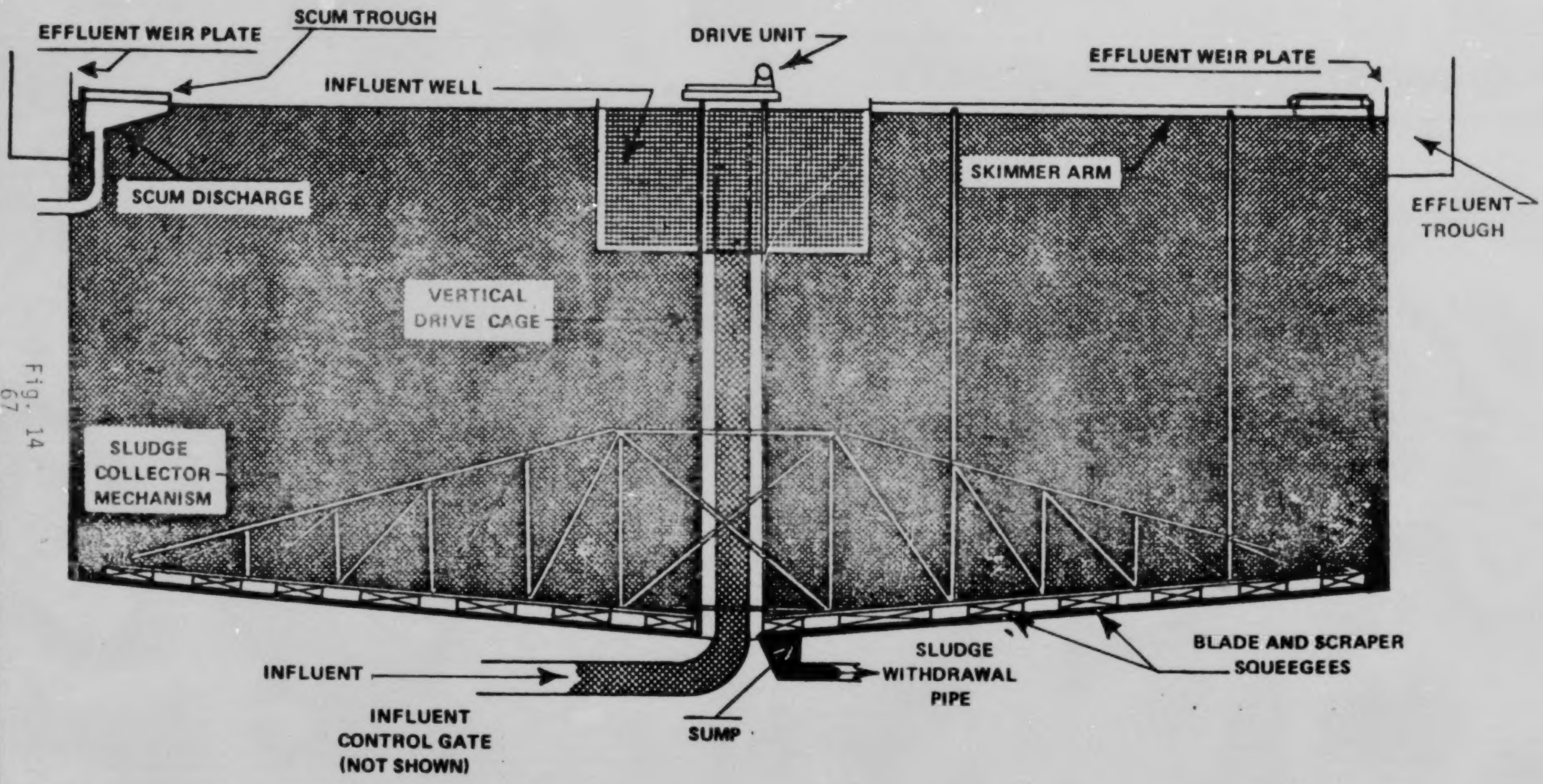
Plan diagram of typical clarifiers in a wastewater treatment plant

Fig. 13
66


NORMAL WATER LEVEL
EFFLUENT WEIR
SCUM BAFFLE
SCUM TROUGH
SCUM SKIMMER
SLUDGE COLLECTOR DRIVE UNIT
INFLUENT CONTROL GATE
EFFLUENT TROUGH (LAUNDER)
ANGLE TRACK
TARGET BAFFLE
INFLUENT
WEARING SHOE
CHAIN AND SCRAPER
MAIN SLUDGE COLLECTOR
SLUDGE CROSS COLLECTOR
SPROCKET
CHAIN AND SCRAPER
SLUDGE WITHDRAWAL PIPE
SUMP
SLUDGE PUMP

Side-view section of a rectangular sedimentation basin

Fig. 14
67


EFFLUENT WEIR PLATE
SCUM TROUGH
DRIVE UNIT
INFLUENT WELL
EFFLUENT WEIR PLATE
SCUM DISCHARGE
SKIMMER ARM
EFFLUENT TROUGH
VERTICAL DRIVE CAGE
SLUDGE COLLECTOR MECHANISM
BLADE AND SCRAPER SQUEEGEES
SLUDGE WITHDRAWAL PIPE
INFLUENT
INFLUENT CONTROL GATE (NOT SHOWN)
SUMP

Side-view section of a circular clarifier with blades and scraper squeegees

Lesson Outline	Lecture Notes
velocities are very slow. 2. Differences between primary clarifiers and secondary clarifiers. 3. Purpose and components in a rectangular sedimentation basin (Table 5.1, Second Edition, and Figures). 4. Purpose and components in a circular clarifier (Table 5.2, Second Edition and Figures). 5.1 Operation and Maintenance 5.10 Start-up Procedure 1. Circular clarifiers 2. Rectangular clarifiers 3. Safety precautions 5.11 Daily Operation and Maintenance 5.12 Shut-down Procedure (2nd Ed.) 5.13 Operational Strategy (2nd Ed.) 1. Purpose: Remove settleable and floatable solids by sedimentation and flotation. 2. Poor effluent may be the result of operator errors or equipment failures.	

Week 6 Hour 1 (Con'd) Chapter: 5
Sedimentation and Floatation

Lesson Outline

3. Removal of settled solids
4. Skimming of floatables

5.14 Abnormal Conditions (2nd Ed.)

1. Toxic wastes from industrial dumps
2. Storm flows and hydraulic overloads.
3. Septicity from collection system problems.

5.15 Trouble-shooting (2nd Ed.)

1. Sludge collector failure
2. Sludge pump failure
3. Toxic waste discharge

5.2 Sampling and Laboratory Analysis

5.20 Need for Sampling and Analysis

1. Measure efficiency of clarifiers
2. Make appropriate process adjustments

5.21 Sampling

Collect a representative sample

5.22 Calculations of clarifier efficiency

Lecture Notes

Week 6 **Hour** 1 (Con'd) **Chapter:** 5
Sedimentation and Flotation

Lesson Outline	Lecture Notes
1. Efficiency, $\% = \frac{(\text{In} - \text{Out})}{\text{In}} \times 100\%$ 2. Work a typical problem 5.23 Typical Clarifier Efficiencies 5.24 Response to Poor Clarifier Performance 1. Solids on surface 2. Loss of solids over effluent weirs 3. Poor efficiencies 4. Pumping thin sludge 5. Mechanical problems 5.3 Sludge and Scum Pumping 1. Septic conditions 2. Sludge gasification 3. Determination of sludge thickness during pumping 5.4 General Maintenance 1. Record keeping 2. Lubrication 3. Inspection 4. Scheduling	

Week 6 Hour 1 (Con'd) Chapter: 5
Sedimentation and Flotation

Lesson Outline	**Lecture Notes**
5.5 Safety 1. Gases 2. Falls 3. Drowning 4. Strains and overexertion 5. Electrical shock	

Week 6 **Hour** 2 **Chapter:** 5
Sedimentation and Flotation

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed Chapter 5, Sedimentation and Flotation Lecture Outline 5.6 Principles of Operation 5.60 Types of Units 1. Primary clarifiers 2. Secondary clarifiers 3. Combined sedimentation-digestion units 4. Flotation units 5. Imhoff tanks 5.61 Primary Clarifiers 1. Purpose: Remove as much settleable and floatable material as possible. 2. Factors influencing design 3. Settling of particles 4. Temperature In general, as water temperature increases, settling rate of particles increases (less viscosity). 5. Short circuits 6. Detention time	

Week 6 **Hour** 2 (Con'd) **Chapter:** 5
Sedimentation and Flotation

Lesson Outline | **Lecture Notes**

Detention time, hours =

$$\frac{\text{Tank Vol, cu. ft.} \times 7.5\ \text{gal/cu. ft.} \times 24\ \text{hr/day}}{\text{Flow, gal/day}}$$

7. Calculate detention time
8. Evaluation and discussion of calculated detention time.
9. Weir overflow rate

$$\text{Weir overflow rate, gpd/ft} = \frac{\text{Flow Rate, gpd}}{\text{Length of weir, ft.}}$$

10. Calculate weir overflow rate
11. Evaluation and discussion of calculated weir overflow rate
12. Surface settling rate or surface loading rate

$$\text{Surface loading rate, gpd/sq.ft.} = \frac{\text{Flow Rate, gpd}}{\text{Area, sq. ft.}}$$

13. Calculate surface loading rate
14. Evaluation and discussion of calculated surface loading rate.
15. Solids loading

$$\text{Solids loading, lbs/day/sq. ft.} = \frac{\text{Solids Applied, lbs/day}}{\text{Surface Area, sq. ft.}}$$

Week 6 **Hour** 2 (Con'd) **Chapter:** 5
Sedimentation and Flotation

Lesson Outline

16. Calculate solids loading
17. Evaluation and discussion of calculated solids loading.

Lecture Notes

Week 6 **Hour** 3 **Chapter:** 5
Sedimentation and Flotation

Lesson Outline

Objectives: Refer to objectives listed in Chapter 5, Sedimentation and Flotation

Lecture Outline

5.62 Secondary Clarifiers

Purpose: To remove settleable solids and any remaining floatables from the effluent of biological treatment processes (trickling filters and activated sludge)

5.620 Trickling filter clarifiers

1. Detention Time - 2.0 to 3.0 hours
2. Surface loading - 800 to 1200 gpd/sq. ft.
3. Weir Overflow - 5,000 to 15,000 gpd/lineal ft
4. Sludge characteristics

5.621 Activated sludge clarifiers

1. Detention Time - 2.0 to 3.0 hours
2. Surface Loading - 300 to 1200 gpd/sq. ft.
3. Weir Overflow - 5,000 to 15,000 gpd/lineal ft.

Lecture Notes

Week 6 **Hour** 3 (Con'd) **Chapter:** 5
Sedimentation and Flotation

Lesson Outline	Lecture Notes
4. Solids Loading - 1.0 to 2.5 lbs/day/ sq. ft. 5. Sludge removal mechanisms 6. Sludge characteristics 7. Return sludge rates (10 to 50% of plant inflow) 8. Wasting activated sludge rates 9. Gravity or flotation sludge thickeners 10. Instrumentation for monitoring conditions in clarifier and operation of clarifier 11. Laboratory testing 5.7 Review of Plans and Specifications (2nd Ed.) 5.70 Operation 5.71 Maintenance 5.72 Safety 5.8 Flotation Processes 1. Vacuum Flotation 2. Pressure Flotation 3. Details on these processes are in the Second Edtion, Volume III.	

Week 6 **Hour** 3 (Con'd) **Chapter:** 5
Sedimentation and Flotation

Lesson Outline

Lecture Notes

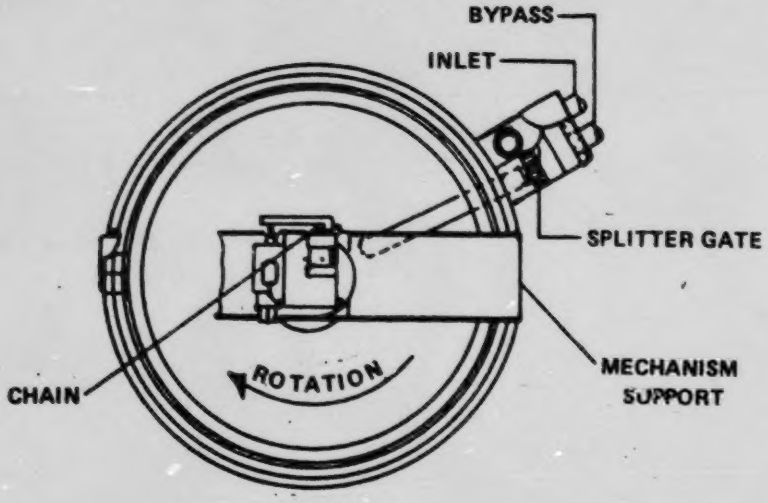
5.9 Combined Sedimentation - Digestion Unit

NOTE: This material is optional. If these typesof units are in your local area they should be discussed.

- 5.90 Purpose of unit
- 5.91 How the unit works
  Purpose and components of sedimentation - digestion unit (Refer to Table 5.3, 2nd Ed. and Figure 15)
- 5.92 Sampling and analysis
  1. Inflow
  2. Clarifier
  3. Digestion
  4. Effluent
- 5.93 Operation
  1. Start-up procedures
  2. Normal operation
  3. Abnormal operation
  4. Shut-down procedures
- 5.94 Maintenance
- 5.95 Safety

5.10 Imhoff Tanks

5.11 Septic Tanks


BYPASS
INLET
SPLITTER GATE
MECHANISM SUPPORT
CHAIN
ROTATION

PLAN

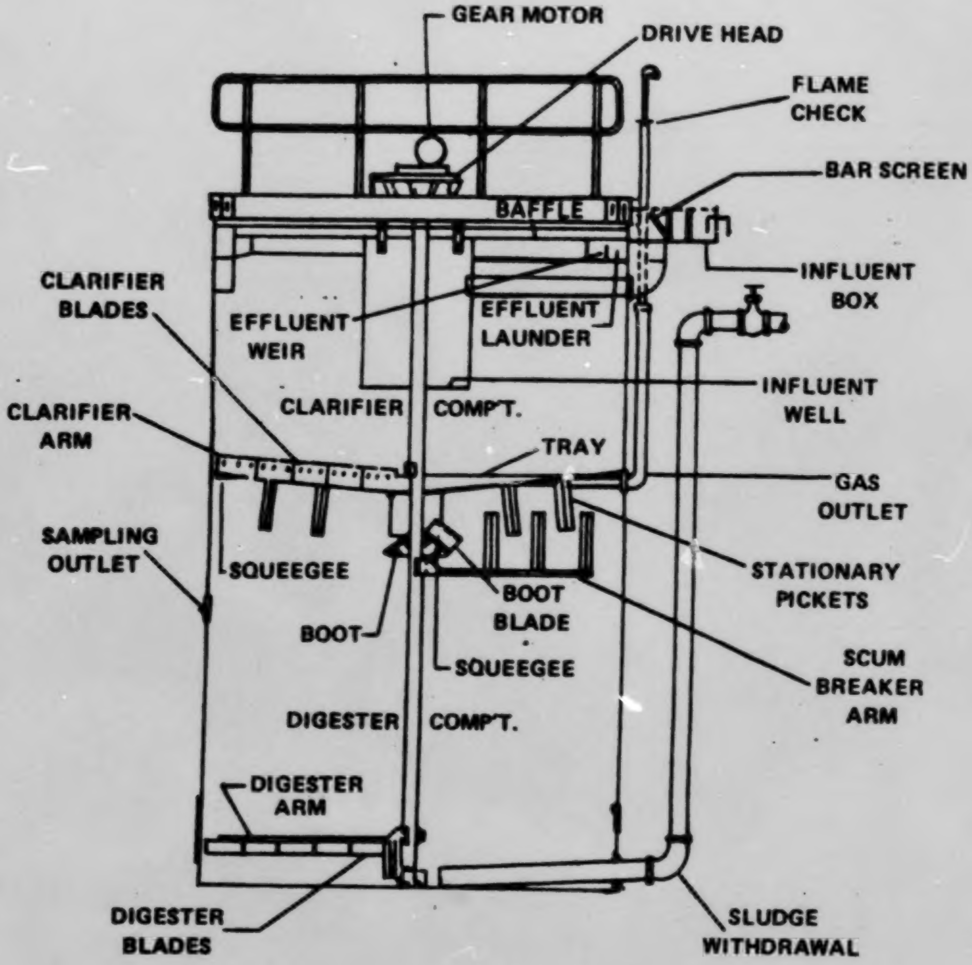

GEAR MOTOR
DRIVE HEAD
FLAME CHECK
BAR SCREEN
BAFFLE
INFLUENT BOX
CLARIFIER BLADES
EFFLUENT WEIR
EFFLUENT LAUNDER
INFLUENT WELL
CLARIFIER COMP'T.
CLARIFIER ARM
TRAY
GAS OUTLET
SAMPLING OUTLET
SQUEEGEE
STATIONARY PICKETS
BOOT
BOOT BLADE
SQUEEGEE
SCUM BREAKER ARM
DIGESTER COMP'T.
DIGESTER ARM
DIGESTER BLADES
SLUDGE WITHDRAWAL

Fig. 15 - Combined sedimentation-digestion unit
(Permission of Dorr-Oliver Incorporated)

Week 6	3 **-Hour** Lab (Optional)	**Chapter:**	5 Sedimentation and Flotation

Lesson Outline	**Lecture Notes**
Objectives: Visit a wastewater treatment plant and observe or help (if possible) the operator operate and maintain a primary circular clarifier and/or a rectangular sedimentation tank.	

CHAPTER 6

TRICKLING FILTERS

Week 7 **Hour** 1 **Chapter:** 6
Trickling Filters

Lesson Outline

Objectives: Refer to objectives listed at the beginning of Chapter 6, Trickling Filters.

Assignment: Discussion and review questions at the end of Lessons 1, 2, and 3 and the objective test at the end of Chapter 6.

Lecture Outline

Glossary: Review new words

6.0 How a Trickling Filter Works
  6.00 Description of a trickling filter.
    Refer to Figures 16, 17 and 18
    1. Describe how filter works
    2. Purpose of trickling filter components (Refer to Table 6.1, 2nd Ed.)
  6.01 Principles of Treatment Process
    1. The media (and retaining structure)
    2. The underdrain system
    3. The distribution system
  6.02 Principles of Operation
    1. The maintenance of a good

Lecture Notes

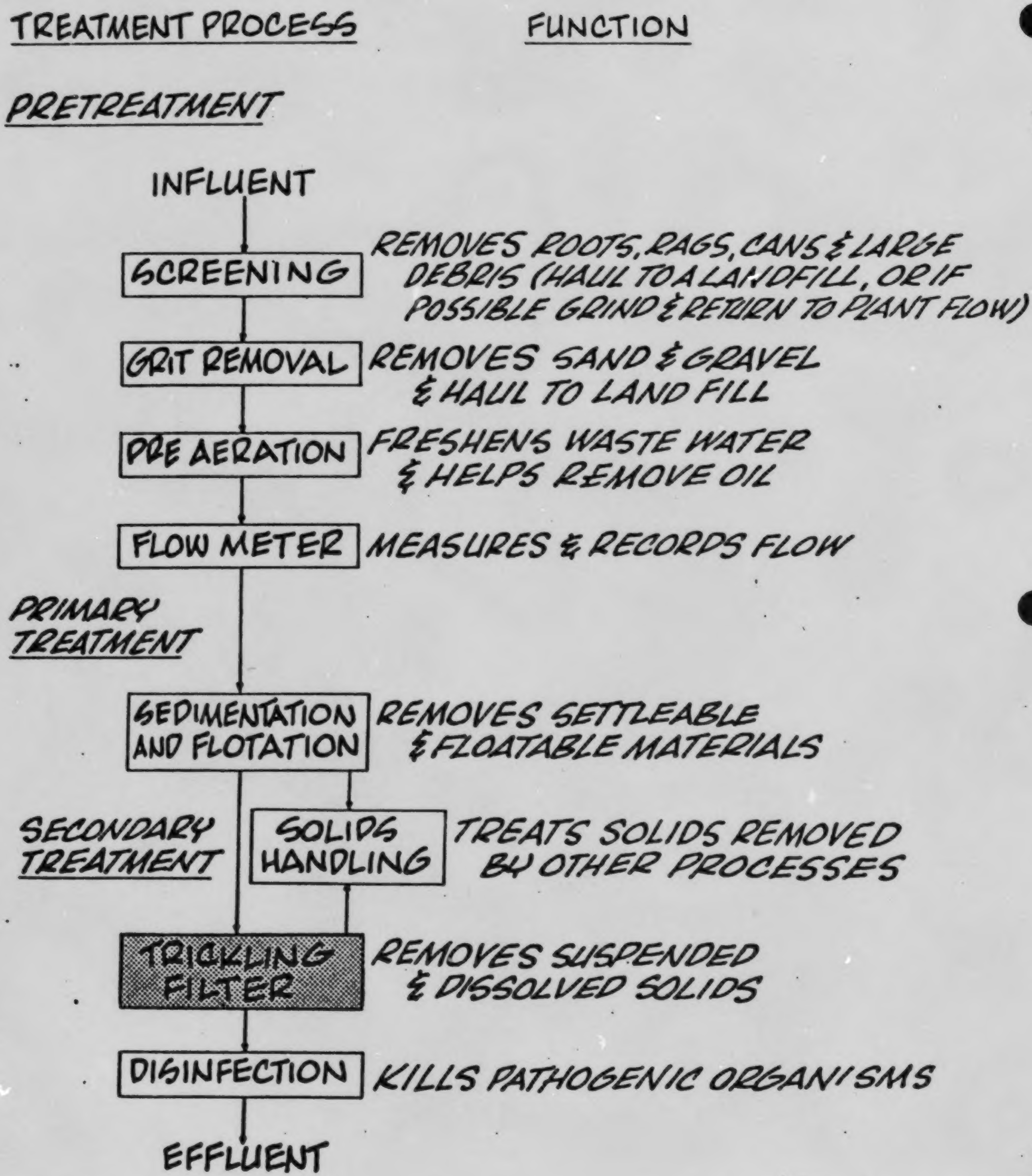
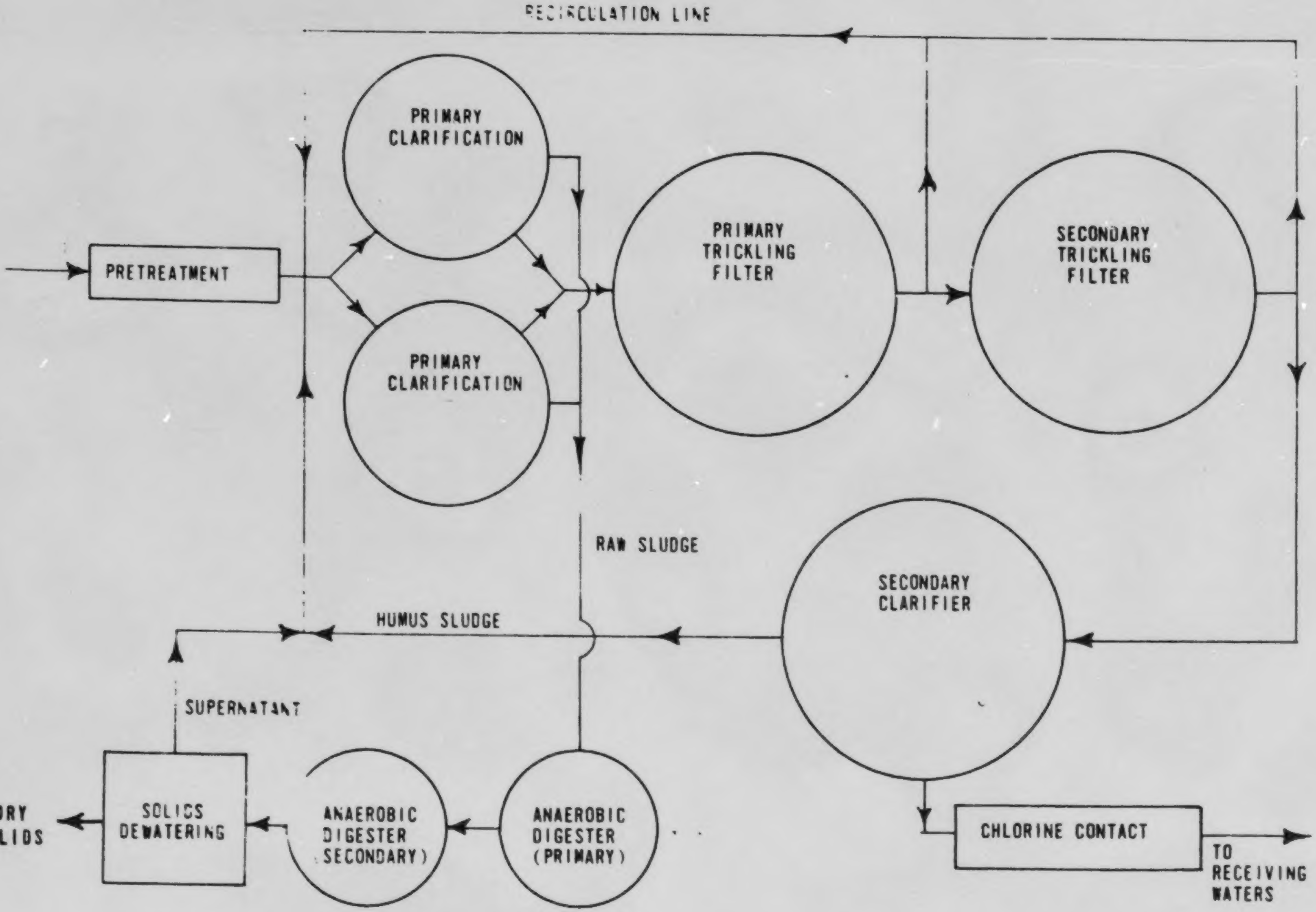

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
TRICKLING FILTER
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 16

Fig. 17


RECIRCULATION LINE
PRIMARY CLARIFICATION
PRIMARY CLARIFICATION
PRETREATMENT
PRIMARY TRICKLING FILTER
SECONDARY TRICKLING FILTER
RAW SLUDGE
SECONDARY CLARIFIER
HUMUS SLUDGE
SUPERNATANT
DRY SOLIDS
SOLIDS DEWATERING
ANAEROBIC DIGESTER SECONDARY)
ANAEROBIC DIGESTER (PRIMARY)
CHLORINE CONTACT
TO RECEIVING WATERS

Plan of typical trickling filter plant

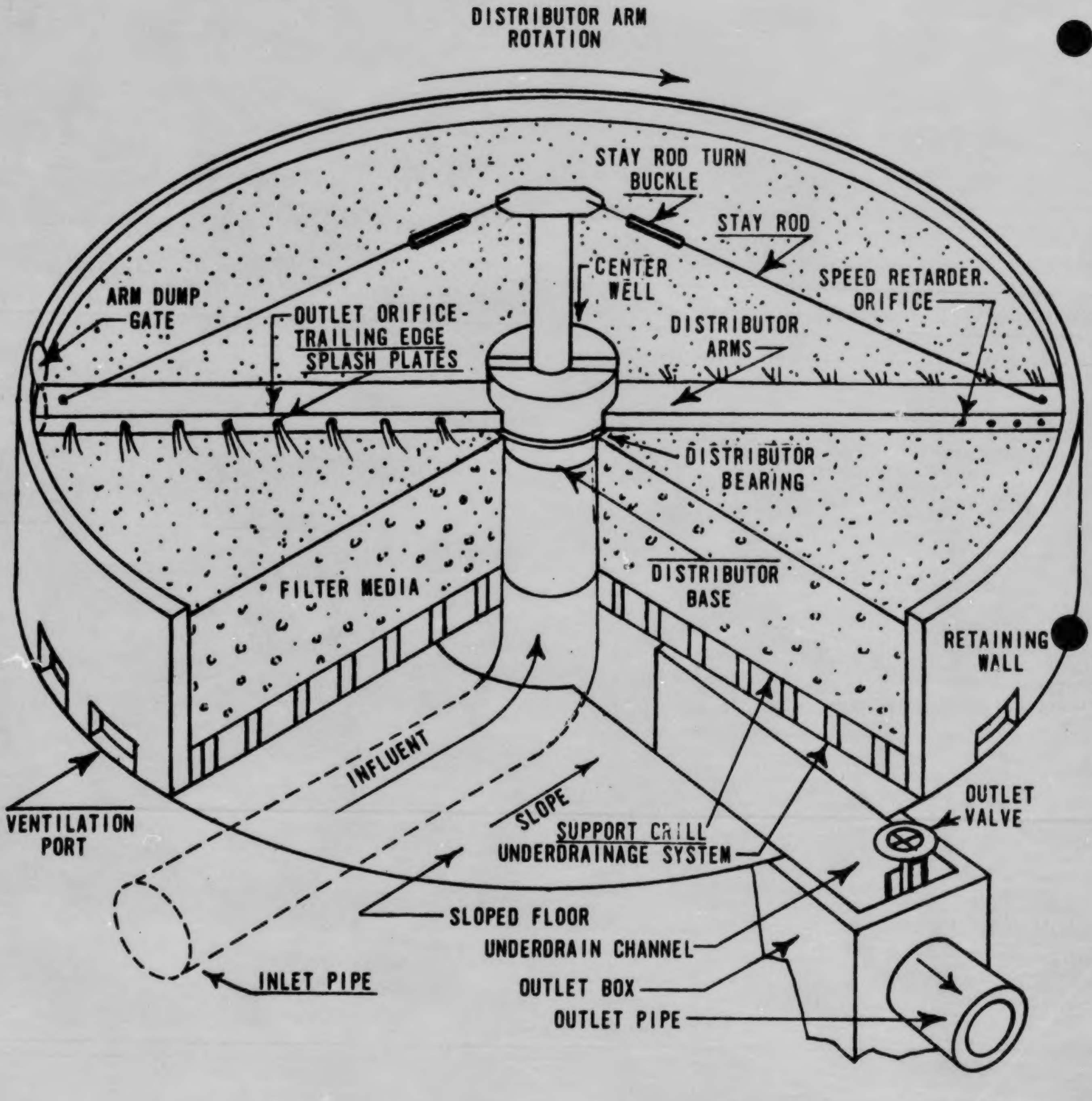

DISTRIBUTOR ARM ROTATION
STAY ROD TURN BUCKLE
STAY ROD
CENTER WELL
SPEED RETARDER ORIFICE
ARM DUMP GATE
OUTLET ORIFICE
TRAILING EDGE SPLASH PLATES
DISTRIBUTOR ARMS
DISTRIBUTOR BEARING
FILTER MEDIA
DISTRIBUTOR BASE
RETAINING WALL
INFLUENT
SLOPE
VENTILATION PORT
SUPPORT GRILL
UNDERDRAINAGE SYSTEM
OUTLET VALVE
SLOPED FLOOR
UNDERDRAIN CHANNEL
INLET PIPE
OUTLET BOX
OUTLET PIPE

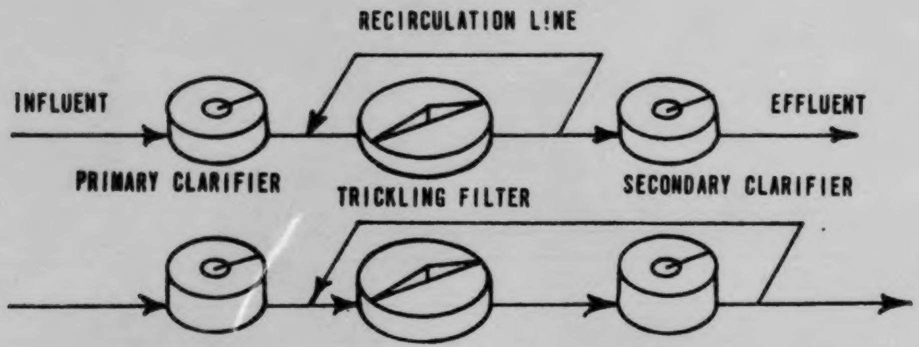
Fig. 18, Trickling filter

Week 7 **Hour** 1 (Con'd) **Chapter:** 6
Trickling Filters

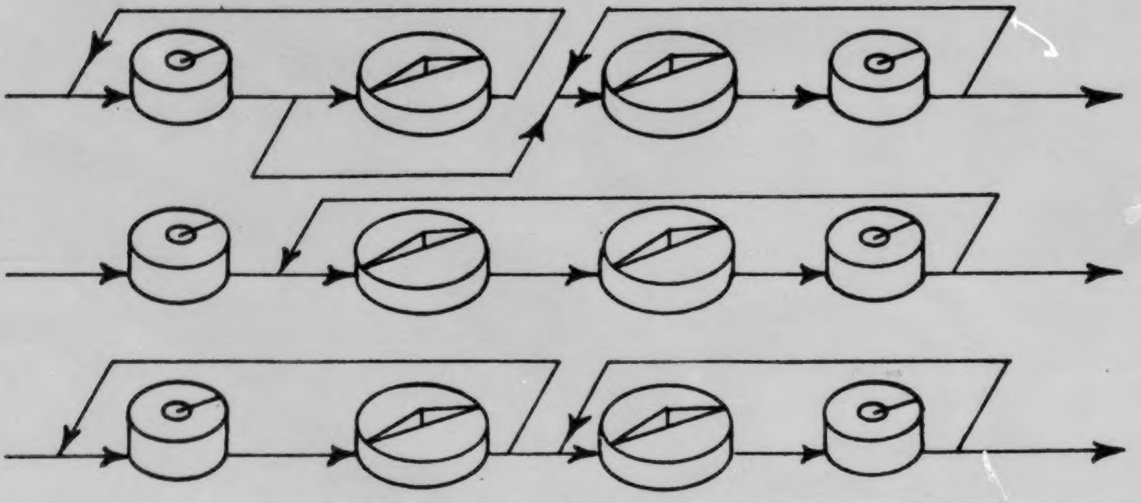
Lesson Outline	**Lecture Notes**
growth of organisms on the filter media is crucial to successful operation. 2. Trickling of water being treated over media 3. Decomposition of wastes 4. Recirculation 5. Efficiency of process 6. Temperature 6.1 Classification of Filters 6.10 General 1. Hydraulic loading, gpd/sq.ft. 2. Organic loading, lbs BOD/day/ 1000 cu. ft. of filter media 6.11 Standard-rate filters 1. Hydraulic loadings, 25 to 100 gpd/sq. ft. 2. Organic(BOD)loadings, 5 to 25 lbs BOD/day/1000 cu. ft. of filter media 3. Depth, 6 to 8 feet 6.12 High-rate filters 1. Hydraulic loadings, 100 to 1000 gpd/sq. ft.	

Week 7 **Hour** 1 (Con'd) **Chapter:** 6
Trickling Filters

Lesson Outline	Lecture Notes
2. Organic (BOD) loadings, 25 to 300 lbs BOD/day/1000 cu. ft. of filter media 3. Depth, 3 to 5 feet 6.13 Roughing Filters Organic loadings over 300 lbs BOD/day/1000 cu. ft. of filter media 6.14 Filter Staging (Refer to Fig. 19, recirculation patterns) 6.2 Starting, Operating and Shutting Down a Filter 6.20 Pre-start up 1. Pre-start up inspections can avoid frustrating and costly delays. 2. Structure and channels 3. Distributor 4. Pumps 5. Valves 6.21 Placing Filter in Service 1. Starting wastewater flowing	


RECIRCULATION LINE
INFLUENT
EFFLUENT
PRIMARY CLARIFIER
TRICKLING FILTER
SECONDARY CLARIFIER

Typical Single-Stage Recirculation Patterns



Typical Two-Stage Recirculation Patterns

Fig. 19, Trickling filter recirculation patterns

Week 7 **Hour** 1 (Con'd) **Chapter:** 6
Trickling Filters

Lesson Outline	Lecture Notes
2. Developing slime growths	
6.22 Daily Operation	
1. Ponding	
2. Filter flies	
3. Odors	
4. Plugged orifices	
5. Roughness or vibration of distributor arms	
6. Leakage past seal	
7. Recirculation	
8. Hydraulic loading	
6.23 Shut Down of a Filter	
1. Inflow	
2. Impact on other treatment processes in plant.	
3. Tools and equipment needed	
4. Work on other equipment while filter out of service	
5. Procedures	
6.3 Sampling and Analysis	
6.30 Important Considerations	
6.31 Typical Trickling Filter Plant Lab Results	

Week 7 **Hour** 1 (Con'd) **Chapter:** 6
Trickling Filters

Lesson Outline	**Lecture Notes**
6.32 Response to Poor Trickling Filter Performance 1. High suspended solids in effluent 2. High BOD in effluent 3. High settleable solids in effluent 4. Low dissolved oxygen (DO) in effluent 5. High chlorine demand 6. Poor clarity 7. High coliform counts	

Week 7 **Hour** 2 **Chapter:** 6
Trickling Filters

Lesson Outline

Objectives: Refer to objectives listed in Chapter 6, Trickling Filters

Lecture Outline

6.4 Operational Strategy

1. Treat daily fluctuations
2. Be prepared to handle shock loads (Hydraulic, organic and toxic).

6.40 Daily Operating Procedures

1. Use the lowest recirculation rates that will produce good results (meet NPDES permit requirements) but not cause ponding or other problems. Low recirculation rates conserve energy and minimize plant operating costs.
2. Daily routine observations
3. Measure and record all important process factors
4. Loading parameters
5. Plant effluent
6. Trend charts
7. Seasonal changes

6.41 Response to Abnormal Conditions

Lecture Notes

Week 7 **Hour** 2 (Con'd) **Chapter:** 6
Trickling Filters

Lesson Outline

1. Ponding
2. Odors
3. Filter flies
4. Weather problems
5. Plant inflow
    a. Storm water infiltration
    b. Broken collection system pipe
    c. Clearance of main line sewer stoppage
    d. Industrial discharges
6. Operational problems with upstream or downstream treatment processes
    a. Screening
    b. Grit
    c. Primary clarifier
    d. Secondary clarifier
    e. Chlorinator

6.42 Trouble-shooting

6.5 Maintenance

6.50 Bearings and seals

6.51 Distributor arms

Lecture Notes

Week 7 **Hour** 2 (Con'd) **Chapter:** 6
Trickling Filters

Lesson Outline	Lecture Notes
6.52 Fixed nozzles 6.53 Underdrains	

Week 7 Hour 3 Chapter: 6
Trickling Filters

Lesson Outline

Objectives: Refer to objectives listed in Chapter 6, Trickling Filters

Lecture Outline

6.7 Loading Parameters

- 6.70 Typical loading rates
  1. Standard-rate filter
  2. High-rate filter
- 6.71 Computing hydraulic loading

$$\text{Hydraulic loading, gpd/sq. ft.} = \frac{\text{Flow Rate, gpd}}{\text{Surface Area, sq.ft.}}$$

  1. Calculate hydraulic loading
  2. Evaluation and discussion of hydraulic loading
- 6.72 Computing Organic (BOD) Loading

$$\text{Organic (BOD) Loading, lbs BOD/day/1000 cu.ft.} = \frac{\text{BOD Applied, lbs/day}}{\text{Vol. of Media in 1000 cu.ft.}}$$

$$\text{BOD Applied, lbs/day} = \text{Flow, MGD} \times \text{BOD, mg/l} \times 8.34\ \text{lbs/gal}$$

  1. Calculate organic (BOD) loading
  2. Evaluation and discussion of organic (BOD) loading.
- 6.73 Typical Loading Rates (metric, 2nd Ed.)
- 6.74 Computing hydraulic loading (metric, 2nd Ed.)

Lecture Notes

Week 7 **Hour** 3 (Con'd) **Chapter:** 6
Trickling Filters

Lesson Outline	**Lecture Notes**
6.75 Computing organic (BOD) loading (metric, 2nd Ed.) 6.8 Review of Plans and Specifications Purpose: a. Become familiar with proposed plant from the plans and specs. b. Learn what will be constructed c. Offer suggestions on how plant can be designed for easier and more effective operation and maintenance. 1. Site 2. Trickling filter structure 3. Equipment 4. Safety	

Week	7	**3-Hour**	Lab (Optional)	**Chapter:** 6 Trickling Filters

Lesson Outline	**Lecture Notes**
Objectives: Visit a trickling filter plant and observe or help (if possible) the operator operate and maintain a trickling filter. NOTE: If a trickling filter plant is not available, you may wish to repeat last week's lab on primary clarifiers at a different treatment plant.	

CHAPTER 7

ROTATING BIOLOGICAL CONTACTORS

(Second Edition)

Week 8 **Hour** 1 **Chapter:** 7
Rotating Biological Contactors
(Second Edition)

Lesson Outline	**Lecture Notes**
Objectives: Refer to objectives listed at the beginning of Chapter 7, Rotating Biological Contractors (SECOND EDITION ONLY) NOTE: You may wish to expand time spent on covering trickling filters and reduce time spent on rotating biological contactors. Some instructors may wish to discuss anaerobic sludge digesters and sand drying beds now instead of during the second semester in Wastewater Treatment II. Assignment: Discussion and review questions at end of the lessons and the objective test at end of Chapter 7 (Second Edition Only). Lecture Outline Glossary: Review new words 7.0 Description of Rotating Biological Contactors. 1. Purpose: Remove organic matter from domestic and industrial wastes. 2. Describe how process works: a. Inflow b. Plastic disc media c. Effluent	

Lesson Outline	**Lecture Notes**
3. Typical plant (Refer to Fig. 21) 4. Purpose of components of a rotating biological contactor (Refer to Table 7.1, 2nd Ed.). 5. Staging (Refer to Fig. 22) 6. Covers 7. Drive assemblies 7.1 Process Operation 1. Performance affected by hydraulic loadings and temperatures below 55 degrees F (13 degrees C) 2. No problems with ponding like trickling filters 7.10 Pretreatment requirements Screening, grit removal, primary settling. 7.11 Start-up 1. Tightness 2. Lubrication 3. Clearance 4. Safety 5. Procedures	

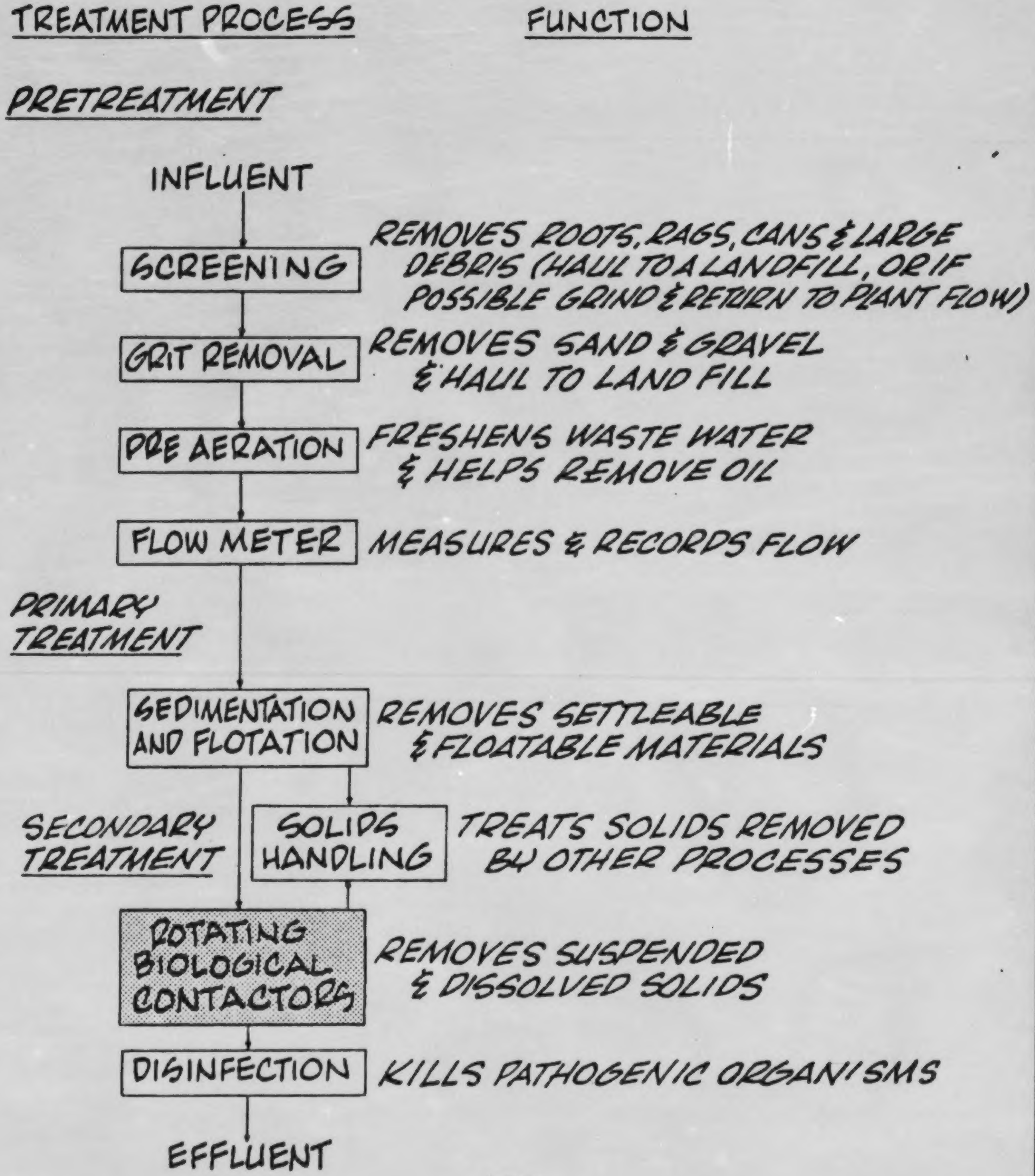
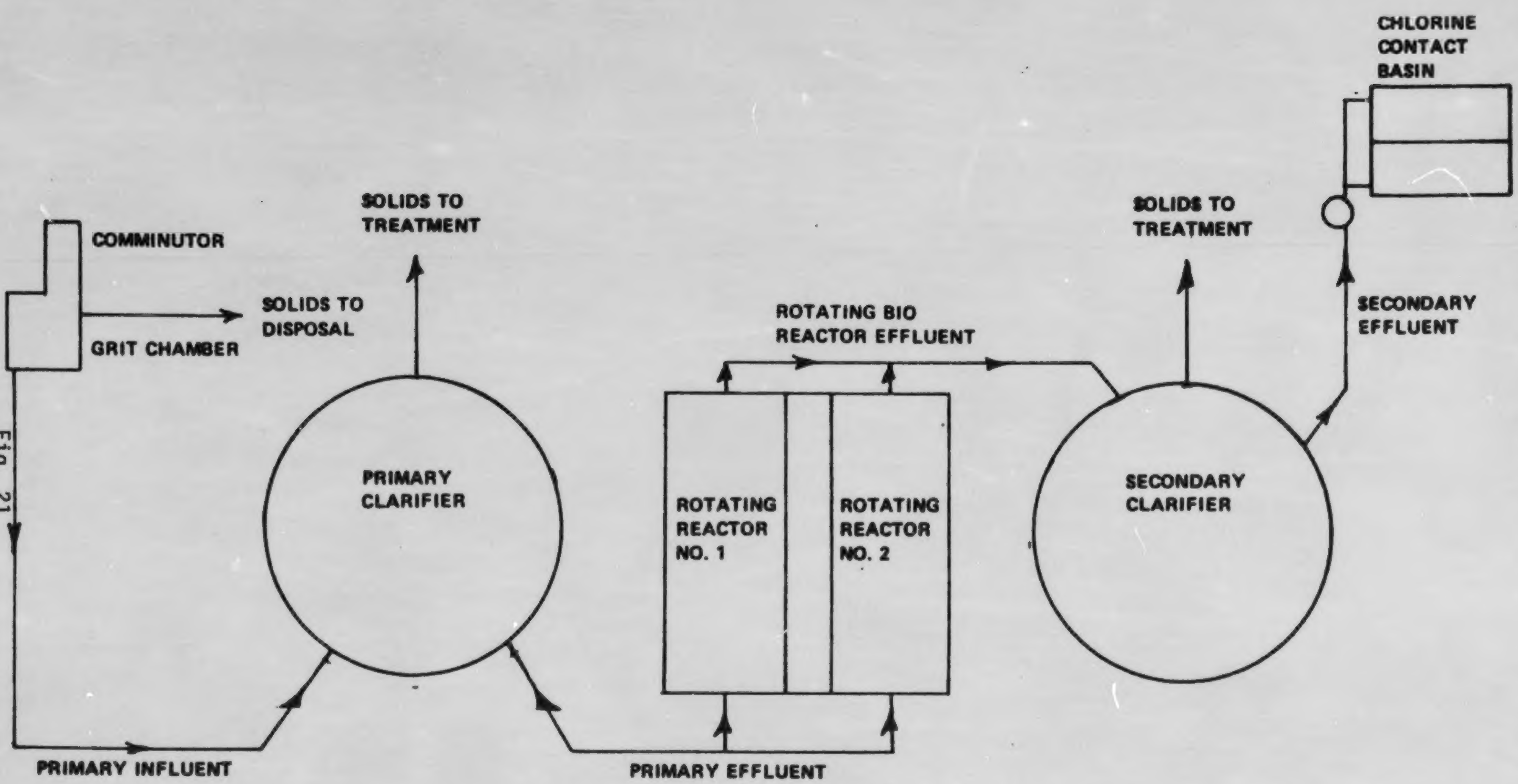
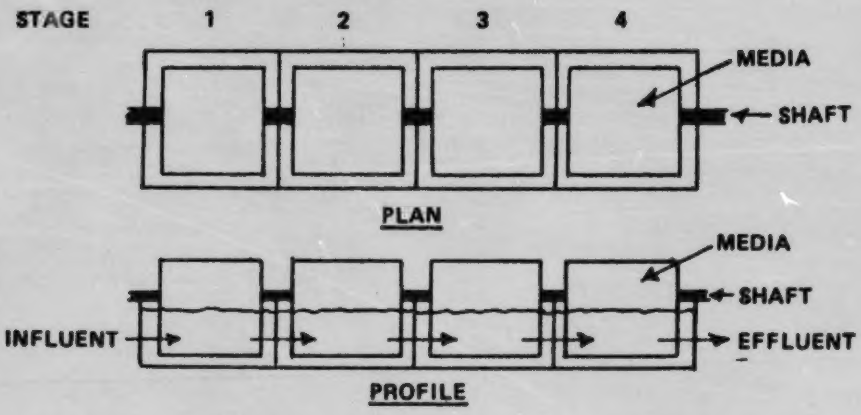

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
ROTATING BIOLOGICAL CONTACTORS
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 20

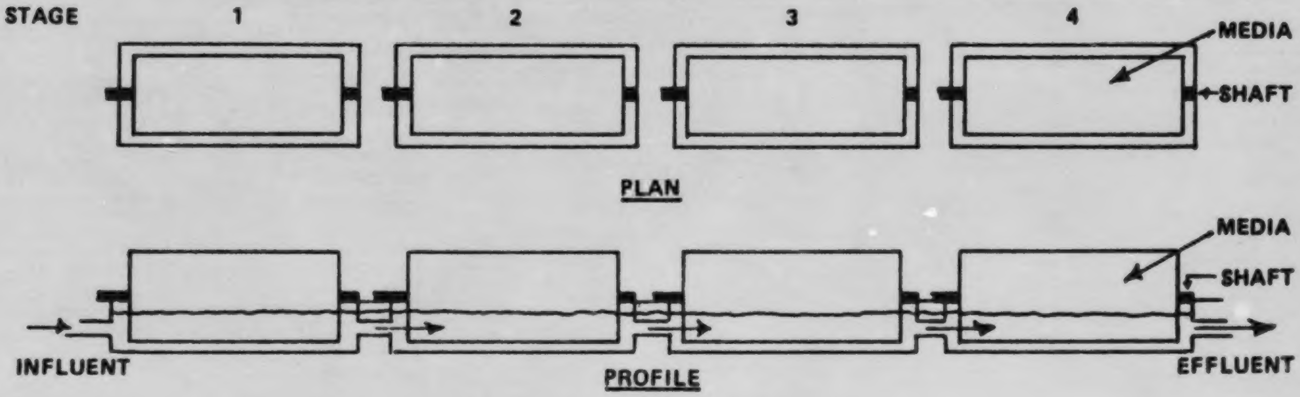
Fig. 21
98


CHLORINE
CONTACT
BASIN
SOLIDS TO
TREATMENT
COMMINUTOR
SOLIDS TO
TREATMENT
SOLIDS TO
DISPOSAL
ROTATING BIO
REACTOR EFFLUENT
SECONDARY
EFFLUENT
GRIT CHAMBER
PRIMARY
CLARIFIER
ROTATING
REACTOR
NO. 1
ROTATING
REACTOR
NO. 2
SECONDARY
CLARIFIER
PRIMARY INFLUENT
PRIMARY EFFLUENT

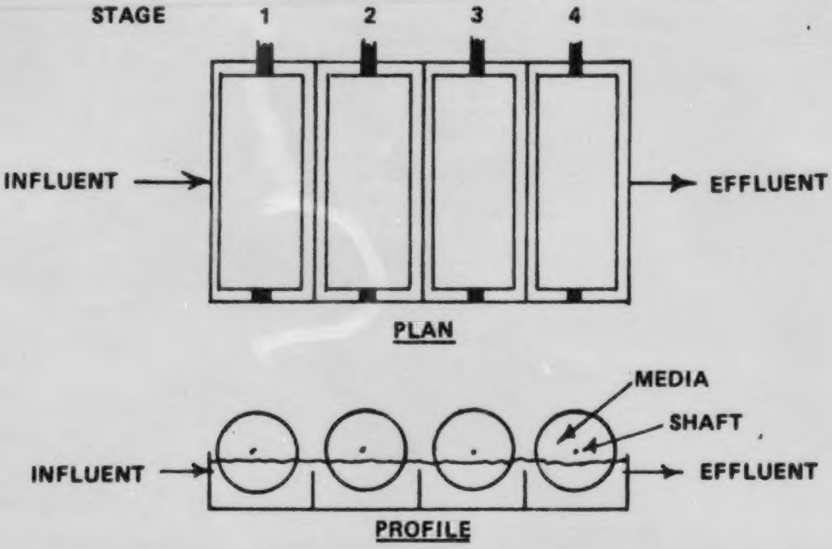
Typical rotating biological contactor treatment plant


STAGE
1
2
3
4
MEDIA
SHAFT
PLAN
MEDIA
SHAFT
INFLUENT
EFFLUENT
PROFILE

LAYOUT NO. 1 ONE SHAFT, FOUR STAGES
FLOW PARALLEL TO SHAFT


STAGE
1
2
3
4
MEDIA
SHAFT
PLAN
MEDIA
SHAFT
INFLUENT
PROFILE
EFFLUENT

LAYOUT NO. 2 FOUR SHAFTS, FOUR STAGES
FLOW PARALLEL TO SHAFT


STAGE
1
2
3
4
INFLUENT
EFFLUENT
PLAN
MEDIA
SHAFT
INFLUENT
EFFLUENT
PROFILE

LAYOUT NO. 3 FOUR SHAFTS, FOUR STAGES
FLOW PERPENDICULAR TO SHAFT

Fig. 22 Possible rotating biological contactor layouts

Week 8 **Hour** 1 (Con'd) **Chapter:**	7 Rotating Biological Contactors (Second Edition)

Lesson Outline	**Lecture Notes**
7.12 Operation 1. Inspecting equipment 2. Testing influent and effluent 3. Observing the media 7.13 Abnormal operation 1. High or low flows 2. High or low solids loadings 3. Power outage 7.14 Shut-down and restart	

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Week 8 **Hour** 2 **Chapter:** 7
Rotating Biological Contactors
(Second Edition)

Lesson Outline	**Lecture Notes**

Objectives: Refer to objectives listed at beginning of Chapter 7, Rotating Biological Contactors (SECOND EDITION ONLY).

Lecture Outline

7.2 Maintenance
  1. Manufacturers' instructions
  2. Plant O&M manual
  3. Preventive maintenance
  7.20 Break-in Maintenance
    1. After 8 hours of operation
    2. After 24 hours operation
    3. After 100 hours operation
    4. After 3 weeks operation
  7.21 Preventive maintenance program
    1. Daily
    2. Weekly
    3. 4 weeks
    4. 3 months
    5. 6 months
    6. 12 months
  7.22 Housekeeping
  7.23 Trouble-shooting
    1. Roller chain drive
    2. Belt drive

Week 8 **Hour** 3 **Chapter:** 7
Rotating Biological Contactors

Lesson Outline	**Lecture Notes**
Objectives: Refer to objectives listed at beginning of Chapter 7, Rotating Biological Contactors (SECOND EDITION ONLY). Lecture Outline 7.3 Safety 1. Moving parts 2. Electrical equipment 3. Slippery surfaces 4. Personal hygiene 7.4 Review of plans and specifications 1. Enclosure or cover 2. Heating Use remaining available time for catch up or review.	

Week 8 3 -Hour Lab (Optional) Chapter: 7
Rotating Biological Contactors

Lesson Outline

Objective: Visit a rotating biological contactor plant and observe or help (if possible) the operator operate and maintain a rotating biological contactor.

NOTE: If a rotating biological contactor is not available, select an appropriate plant to visit and help the operator with some aspect of maintenance and operation.

Lecture Notes

Week 9 **Hour** 1 **Chapter:** 5 through 7

Lesson Outline

Objective: Review for Exam II

1. Cover important material since last exam.
2. Emphasize purpose of processes, equipment and components.
3. Discuss start-up, normal and abnormal operation, and shut down of processes and equipment.
4. Outline maintenance procedures.
5. Review safety hazards and safe procedures.
6. Identify important items that should be considered when reviewing plans and specifications.
7. Outline trouble-shooting procedures.

Lecture Notes

Week 9	**Hour** 2	**Chapter:** 5 through 7

Lesson Outline	**Lecture Notes**
Objective: Exam II	

Week 9 **Hour** 3 **Chapter:** 5 through 7

Lesson Outline

Objectives:

1. Review results of Exam II and correct all mistakes or errors.
2. Identify areas for future review and students who need additional help.

NOTE:

1. If Exam II is not graded, continue on to Week 10, Hour 1, and review exam when available.
2. Some instructors may wish to schedule exams less frequently or more frequently and should feel free to do so.

Lecture Notes

Week 9 3-Hour Lab (Optional) Chapter:

Lesson Outline	Lecture Notes
Suggest instructor schedule visit to treatment plant where operator may need help with a maintenance or repair job.	

CHAPTER 7

ACTIVATED SLUDGE

(First Edition)

or

CHAPTER 8

ACTIVATED SLUDGE

(Second Edition)

Week 10 **Hour** 1 **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part 1, Package Plants and Oxidation Ditches

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of.

1. Chapter 7, Activated Sludge (First Edition)

or

2. Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition).

Assignment: Discussion and review questions at end of lesson and objective test (appropriate portions), Chapter 7, (First Edition), or Chapter 8 (Second Edition).

Lecture Outline

Glossary: Review new words

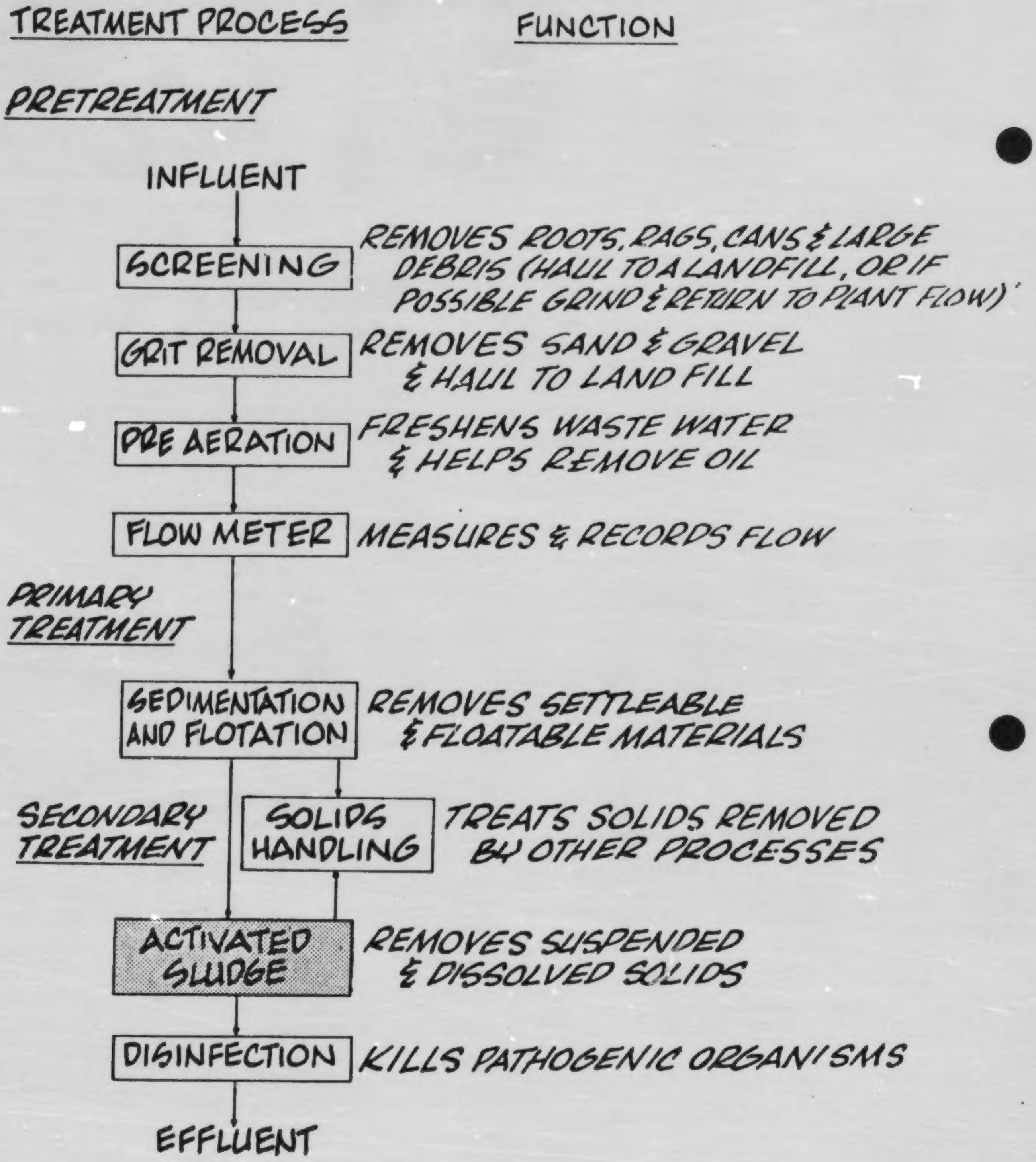
8.0* The Activated Sludge Process.

Process treats wastewater from:

1. Primary clarifier (most common); or
2. Raw wastewater.
3. Refer to flow diagram of treatment processes.

* Numbers for Second Edition: Subtract 1.0 for first edition, 7.0. The Activated Sludge Process.

Lecture Notes


PRETREATMENT
INFLUENT
PRIMARY TREATMENT
SECONDARY TREATMENT
EFFLUENT

TREATMENT PROCESS	FUNCTION
PRETREATMENT	
SCREENING	REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL	REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION	FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER	MEASURES & RECORDS FLOW
PRIMARY TREATMENT	
SEDIMENTATION AND FLOTATION	REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT	
SOLIDS HANDLING	TREATS SOLIDS REMOVED BY OTHER PROCESSES
ACTIVATED SLUDGE	REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION	KILLS PATHOGENIC ORGANISMS

Fig. 23

Week 10 **Hour** 1 (Con'd) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part 1

Lesson Outline

8.01 Definitions

1. Activated sludge
2. Activated sludge process

8.02 Process Description

1. Purpose: Oxidation and removal of soluble or finely divided suspended materials that were not removed by previous treatment
2. Materials removed by aerobic organisms within a few hours when the water is being treated while it flows through the aeration tank.
3. Liquid-organism (water-solids) separation occurs in a secondary clarifier after aeration.
4. Clarifier effluent is usually chlorinated prior to discharge to receiving waters.
5. Clarifier effluent may receive additional treatment

Lecture Notes

Lesson Outline	Lecture Notes
prior to chlorination depending on uses of receiving water or if wastewater is reclaimed for some use.	

Week 10 **Hour** 2 **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

Objectives: Refer to objectives listed at the beginning of:

1. Chapter 7, Activated Sludge (First Edition);

or

2. Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition).

Lecture Outline

8.1 Requirements for Control

1. Effluent quality requirements
   a. NPDES Permit
   b. BOD
   c. Suspended solids
   d. Settleable solids
   e. Coliform group bacteria (MPN)
2. Wastewater flow, waste concentrations, and characteristics
   a. Municipal ordinances
   b. Control or monitoring of industries
3. Amount of activated sludge (containing the working organisms) to be maintained in the process

Lecture Notes

Lesson Outline	Lecture Notes
relative to inflow. a. Organism competition for food b. Food to Microorganism (F/M) ratio is a primary control in the activated sludge process. c. Organisms tend to increase with waste (food) load and time spent in the aeration tank. 4. Under favorable conditions the operator will remove (sludge wasting) the excess organisms to maintain the required number of "workers" for effective waste treatment. Therefore, the removal of organisms from the treatment process (sludge wasting) is a very important control technique. 5. Sufficient oxygen is necessary to sustain the living organisms for the oxidation of wastes to obtain energy for growth. Either insufficient oxygen or excess oxygen	

Week 10 **Hour** 2 (Con'd)**Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline	**Lecture Notes**
can cause operating problems. 6. Flows must be divided evenly among two or more treatment units. 7. Activated sludge solids concentrations in the aerator and the secondary clarifier should be determined by the operator for control purposes. The activated sludge solids in the aerator indicate the microorganisms that are available to treat the incoming wastes. Settleability tests of the mixed liquor from the clarifier show the degree and volume of solids settling that may be obtained in a secondary clarifier. A visual examination of the secondary clarifier reveals what is actually happening. 8. Activated sludge tends to convert soluble solids to suspended cell mass material and to gather and	

Week 10 Hour 2 (Con'd) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline	Lecture Notes
agglomerate particles too fine to settle rapidly into readily separated material. 9. There must be organisms, oxidizing conditions, and suitable time to cause the conversion of soluble solids and to agglomerate the fine particles to form a floc mass. 10. When a floc mass is returned to the aerator from the final clarifier, the organisms grow as a result of taking food from the inflowing wastewater. The surface of the floc mass is irregular and promotes the transfer of wastewater pollutants into the solids by means of mechanical entrapment, absorption, adsorption, or adhesion. 11. Material taken into the floc mass is partially oxidized to form cell mass and oxidation products. Mixing in the areator promotes collisions and thus produces larger floc mass.	

Week 10 **Hour** 2 (Con'd) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline	Lecture Notes
12. Growth of organisms and accumulated residues produce solids for disposal (waste activated sludge). Maintain as high a concentration of solids in the return sludge as possible to reduce the amount of water needed to return these solids back to the aerator. 13. Don't pump waste activated sludge directly to an anaerobic digester because it will return to the aeration tank as supernatant with an added load on the organisms. Pump waste activated sludge to influent of primary clarifiers or sludge thickeners. 14. To maintain the working organisms in the activated sludge, you must provide a suitable environment. Intolerable concentrations of acids, bases, and other toxic substances are undesirable and may kill the working organisms.	

Week 10 **Hour** 2 (Con'd) **Chapter:**	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline	Lecture Notes
Unduly fluctuating loads may cause overfeeding, starvation, and other factors that are all capable of upsetting the activated sludge process. Insufficient oxygen can cause an unfavorable environment which results in decreased organism activity. 15. Control of the activated sludge process consists of maintaining the proper solids (floc mass) concentration in the aerator for the waste (food) inflow by adjusting the waste sludge pumping rate and regulating the oxygen supply to maintain a satisfactory level of dissolved oxygen in the process.	

Week 10 **Hour** 3 **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline	Lecture Notes
Objectives: 1. Review material covered during last 2 hours to thoroughly understand how the activated sludge process works. 2. Use remaining time in hour to catch up or to move ahead and start material on package plants.	

Week 10 3 **-Hour** Lab (Optional) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline	Lecture Notes
Objective: Visit an activated sludge plant and observe or help (if possible) the operator operate and maintain the activated sludge process.	

Week 11 **Hour** 1 **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

Objectives: Refer to objectives listed at the beginning of:

1. Chapter, 7, Activated Sludge (First Edition)

or

2. Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition)

Assignment: Discussion and review questions at end of lesson on package aeration plants.

Lecture Outline

8.2 Package Plants

8.20 Purpose of Package Plants

8.200 Use of Package Plants

1. Operation of small package plants is similar to the operation of any other activated sludge plant.
2. A high quality effluent requires attention, understanding, and good plant operation.
3. Two compartments or three compartments

Lecture Notes

Week 11 **Hour** 1 (Con'd) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

Lecture Notes

8.201 Types of Package Plant Processes

1. Extended aeration
2. Contact stabilization
3. Complete mix

8.202 Aeration Methods

1. Mechanical aeration
2. Diffused aeration

8.21 Pre-start check-out

While the tank is empty, check the following:

1. Tank must be level
2. If metal tank, cathodic protection required.
3. Condition of paint
4. Remove all rocks and debris
5. Check any preliminary treatment equipment (comminutor)
6. Inspect aeration device
7. Record and file important data
8. Check influent gate or valve for proper operation.

Week 11 **Hour** 1 (Con'd)**Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline	Lecture Notes
8.22 Starting the Plant 1. Fill tank 2. Start aeration equipment 3. Return flows to aeration tank 4. Foam control	

Week 11 **Hour** 2 **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of:

1. Chapter 7, Activated Sludge (First Edition)

or

2. Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition)

Lecture Outline

8.23 Operation of Aeration Equipment

1. Operate aeration equipment continuously. Good treatment rarely results from interrupted operation and should not be attempted. How would you like to be given too much air, just the right amount, and then not enough air? Do you think you could do a good job under these conditions?
2. If the water is murky or cloudy and the aeration compartment has a rotten egg

Lecture Notes

Week 11 **Hour** 2 (Con'd) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

odor (H_2S), insufficient air is supplied and the air supplied or aeration rate should be increased.

3. If the water is clear in the settling compartment, the aeration rate is probably sufficient.
4. If you can measure the dissolved oxygen (DO) in the aeration tank, the DO should be around 2 mg/l THROUGHOUT the aeration tank (top and bottom, along sides and at both ends)

8.24 Wasting Sludge

1. Waste about 5 percent of the solids each week.
2. Allow solids to settle to bottom of settling compartment for about one hour.
3. Pump solids to
    a. Drying beds if odors are not a problem.

Lecture Notes

Week 11 **Hour** 2 (Con'd) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline	Lecture Notes
b. An aerated holding tank for ultimate disposal at an approved sanitary landfill. c. A septic tank pumper's truck for disposal at an approved sanitary landfill. 4. Frequency and amount of wasting should be revised periodically on basis of performance of plant. You do not want an excessive amount of solids in your plant effluent. 5. A white, fluffy foam indicates low solids content in the aerator, while a brown, leathery foam suggests high solids concentration.	

Week 11 Hour 3 Chapter: 7, Activated Sludge, (First Edition)
or
8, Activated Sludge, (Second Edition)
Part I

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of,

1. Chapter 7, Activated Sludge (First Edition)

or

2. Chapter 8, Activated Sludge, Part I, Package Plant and Oxidation Ditches (Second Edition)

Lecture Outline

8.25 Operation

8.250 Normal Operation

1. Items to check each day
   - a. Visual
   - b. Sound
   - c. Feel equipment for vibrations and temperatures
   - d. Smell for odors

8.251 Abnormal Operation

1. Toxic wastes such as pesticides, detergents, solvents or high or low pH levels.
2. Excessively high or low flows or solids (organic)

Lecture Notes

Week 11 **Hour** 3 (Con'd) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

loadings.

8.252 Trouble-shooting

1. Solids in effluent
2. Odors
3. Foaming/frothing

8.253 Shut Down

1. Depends on type of plant
2. Beware of high ground water levels that could float empty compartments

8.26 Laboratory Testing

1. Settling test
2. Solids settle half way down
3. Solids settle to bottom and come back up
4. Other lab tests

8.27 Safety

1. Toxic gases
2. Dangerous chemicals
3. Electrical hazards
4. If you must work alone, phone your office at regular intervals.

Lecture Notes

Week 11 **Hour** 3 (Con'd) **Chapter:** 7, Activated Sludge (First Edition
or
8, Activated Sludge (Second Edition
Part I

Lesson Outline	**Lecture Notes**
8.28 Maintenance 1. Cleanliness 2. Equipment	

Week 11 3-Hour Lab (Optional) **Chapter:**	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I
Lesson Outline Objective: Visit a package activated sludge plant and observe or help (if possible) the operator operate and maintain the activated sludge process. If a package plant is not available, visit a conventional activated sludge plant.	**Lecture Notes**

Week 12 **Hour** 1 **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

Lecture Notes

Objectives: Refer to the objectives at the beginning of Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition)

Assignment: Discussion and review questions at end of lesson on oxidation ditches and objective test at end of Chapter 8 (Second Edition).

Lecture Outline

8.3 Oxidation Ditches (Second Edition)

8.30 Use of Oxidation Ditches

8.300 Flow path for oxidation ditches

1. Refer to figure showing oxidation ditch flow path
2. The oxidation ditch is a modified form of the activated sludge process and is usually operated in the extended aeration mode.
3. Principle components include oxidation ditch, brush rotor assembly, settling tank, return sludge pump, and excess sludge handling facilities.

Week 12 **Hour** 1 (Con'd) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)

Lesson Outline

4. Purpose of components in an oxidation ditch (Refer to Table 8.1, Second Edition).
5. Describe how process works.
6. Disposal of effluent
7. BOD removals above 90% and as high as 98%

8.301 Description of Oxidation Ditches

1. Performance of ditches
2. Operational criteria

8.31 Safety

1. Safety is a "life-style"
2. Wear proper shoes, gloves and clothing
3. Avoid slippery surfaces and clean up spills
4. Keep area neat and uncluttered
5. Do not walk on top of oxidation ditch walls or you may fall into ditch.

Lecture Notes

Week 12 **Hour** 2 **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition)

Lecture Outline

8.32 Start up

1. Make certain that all mechanical equipment is operating properly.
2. Develop the proper microbial floc (activated sludge) in the oxidation ditch. This floc is essential for the plant to succeed in reducing the quantities of polluting materials in the wastewater.

8.320 Pre-start inspection

1. Inlet structure
2. Ditch structure
3. Rotor
4. Adjustable weir
5. Clarifier structure and components
6. Return sludge and waste sludge

Lecture Notes

Lesson Outline	**Lecture Notes**
systems. 7. Pumps and valves 8.321 Plant Start up 1. Fill ditch with water 2. Obtain healthy "seed" activated sludge 3. Color of MLSS 4. Allow depth of ditch to get as high as possible to retain microorganisms. 5. Chlorination of effluent 6. Wastewater testing procedures 7. DO in ditch 8. Time to reach stabilization 9. Following start up, when the plant has stabilized, the solids should settle rapidly in the clarifier leaving a clear, odorless and stable effluent. The solids should look like particles, golden to rich dark brown in color, with sharply defined edges.	

Week 12 **Hour** 3 **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition)

Lecture Outline

8.33 Operation

8.330 Normal Operation

1. Food supply for the microorganisms
2. DO levels (water level in ditches)
3. Environment
4. Treatment time
5. Water/solids separation
6. Observations
   a. Color
   b. Odor
   c. Clarity
   d. Records
   e. Plant Survey

8.331 Abnormal Operation

1. Motor
2. Gear reducer
3. Bearings

Lecture Notes

Week 12 **Hour** 3 (Con'd) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

4. Environmental factors (temperature and precipitation)
5. Hydraulic and organic overloads

8.332 Shut down

1. Scheduling
2. Rotor

8.333 Trouble-shooting

1. See Section 8.252, Trouble-shooting, for package plants.
2. Floatables in final settling tank

8.34 Maintenance

1. General housekeeping
2. Equipment maintenance
    a. Motors
    b. Gear reducer
    c. Bearings
    d. Lubrication

8.35 Operational criteria (both English and Metric Systems)

1. Oxidation ditch dimensions
2. Flow and waste characteristics
3. Oxidation ditch volume

Lecture Notes

Week 12 **Hour** 3 (Con'd) **Chapter:** 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline

4. BOD loading
5. Food/microorganism ratio
6. Sludge age
7. Ditch detention time

Lecture Notes

Week 12 3-Hour Lab (Optional) Chapter: 7, Activated Sludge (First Edition)
or
8, Activated Sludge (Second Edition)
Part I

Lesson Outline	Lecture Notes
Objective: Visit an oxidation ditch plant and observe or help (if possible) the operator operate and maintain the oxidation ditch. If an oxidation ditch is not available, visit an activated sludge plant.	

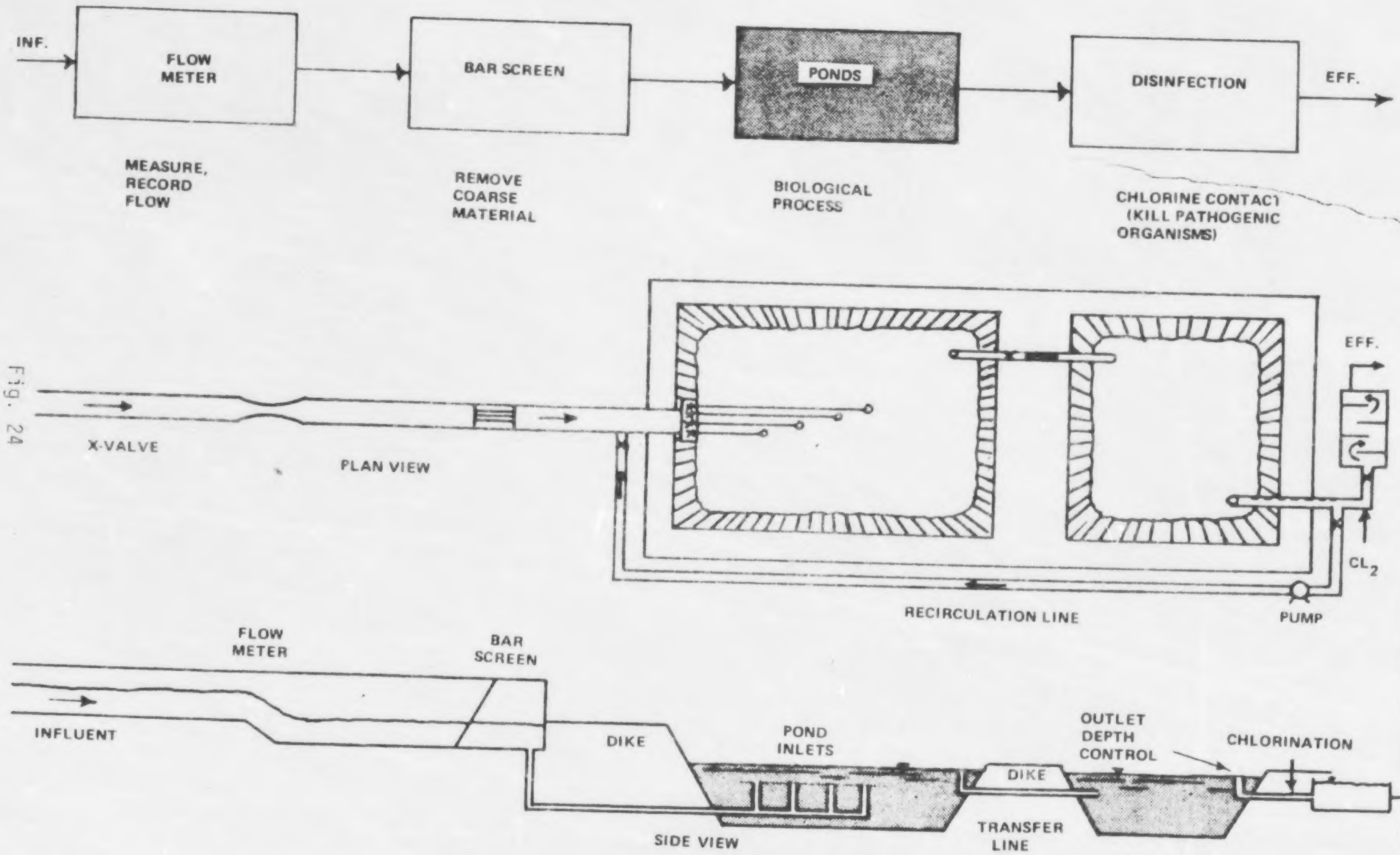
CHAPTER 9

WASTE TREATMENT PONDS

Week 13 **Hour** 1 **Chapter:** 9
Waste Treatment Ponds

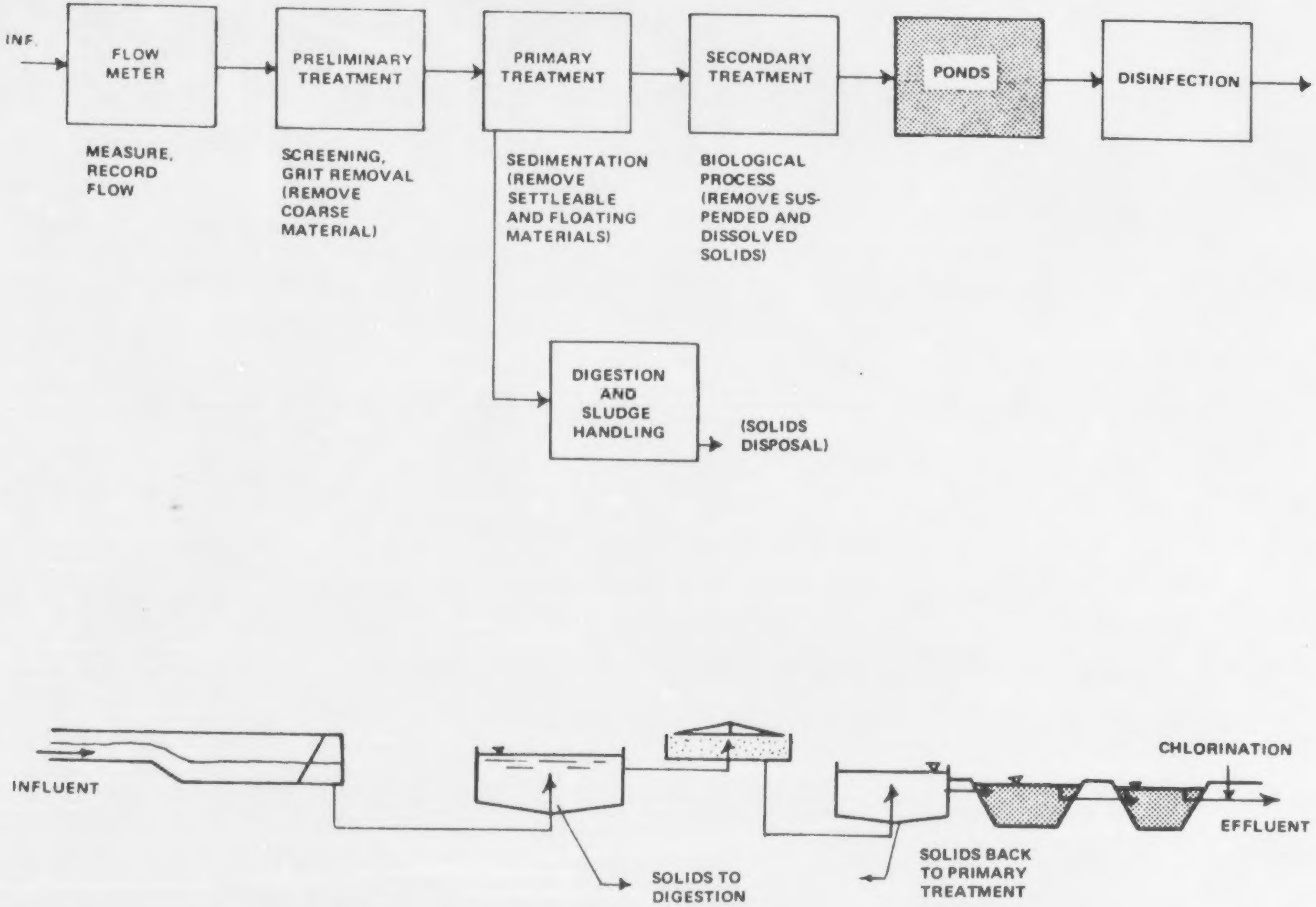
Lesson Outline	Lecture Notes
Objectives: Refer to the objectives listed at the beginning of Chapter 9, Waste Treatment Ponds. Assignment: Discussion and review questions at the end of each lesson and the objective test at the end of Chapter 9. Lecture Outline Glossary: Review new words 9.1 Use of Ponds 1. Treatment of wastewater instead of conventional waste treatment processes 2. Treatment of wastewater in addition to (after) conventional waste treatment processes. 3. Breakdown of wastes 4. Typical pond layout (Refer to Figures 24 and 25) 5. Purpose of pond components (Refer to Table 9.1, Second Edition) 9.2 History of Ponds in Waste Treatment 1. Early uses 2. Advantages for smaller installations	

Fig. 24
139


INF.
FLOW METER
BAR SCREEN
PONDS
DISINFECTION
EFF.
MEASURE, RECORD FLOW
REMOVE COARSE MATERIAL
BIOLOGICAL PROCESS
CHLORINE CONTACT (KILL PATHOGENIC ORGANISMS)
EFF.
X-VALVE
PLAN VIEW
CL2
RECIRCULATION LINE
PUMP
FLOW METER
BAR SCREEN
INFLUENT
DIKE
POND INLETS
OUTLET DEPTH CONTROL
DIKE
CHLORINATION
SIDE VIEW
TRANSFER LINE

Typical plant; ponds only

Fig. 25


INF.
FLOW METER
MEASURE, RECORD FLOW
PRELIMINARY TREATMENT
SCREENING, GRIT REMOVAL (REMOVE COARSE MATERIAL)
PRIMARY TREATMENT
SEDIMENTATION (REMOVE SETTLEABLE AND FLOATING MATERIALS)
SECONDARY TREATMENT
BIOLOGICAL PROCESS (REMOVE SUSPENDED AND DISSOLVED SOLIDS)
PONDS
DISINFECTION
DIGESTION AND SLUDGE HANDLING
(SOLIDS DISPOSAL)
INFLUENT
SOLIDS TO DIGESTION
SOLIDS BACK TO PRIMARY TREATMENT
CHLORINATION
EFFLUENT

Typical plant; ponds after secondary treatment

Week 13 **Hour** 1 (Con'd) **Chapter:** 9
Waste Treatment Ponds

Lesson Outline

Lecture Notes

9.3 Pond Classifications and Applications (Refer to Fig. 26)

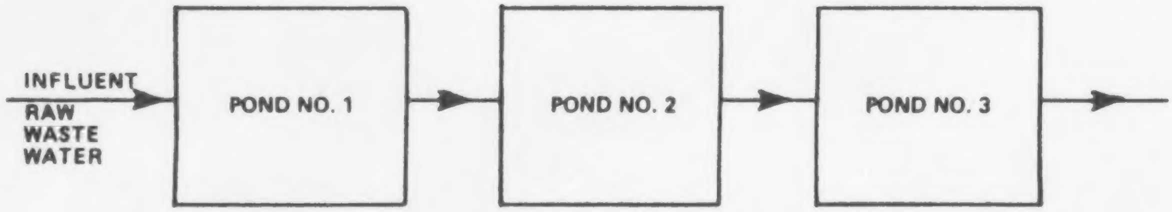
1. Raw wastewater lagoon or stabilization ponds
2. Oxidation ponds
3. Polishing ponds
4. Aerobic, anaerobic and facultative ponds

9.4 Explanation of Treatment Process (Refer to Fig. 27)

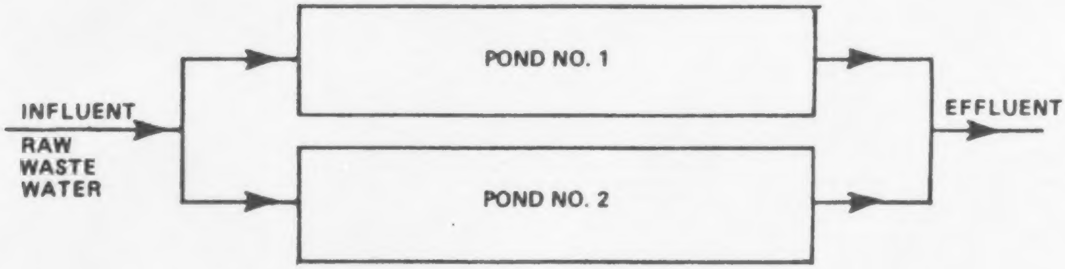
1. Role of algae
2. Production of oxygen
3. Anaerobic ponds or anaerobic layer
4. Sludge decomposition and storage
5. Methane fermentation

9.5 Pond Performance

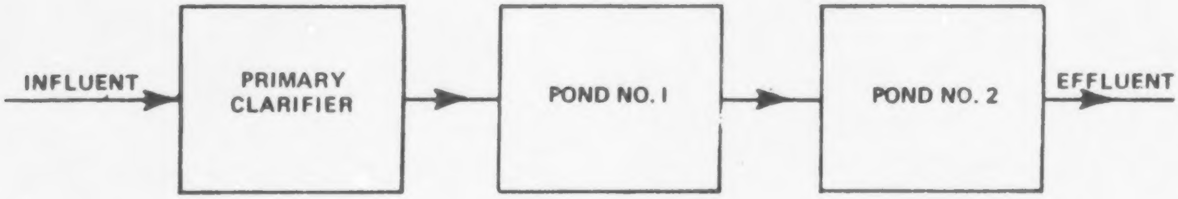
1. Physical factors
2. Chemical factors
3. Biological factors
4. Treatment efficiencies
5. Detention times


INFLUENT
RAW WASTE WATER
POND NO. 1
POND NO. 2
POND NO. 3

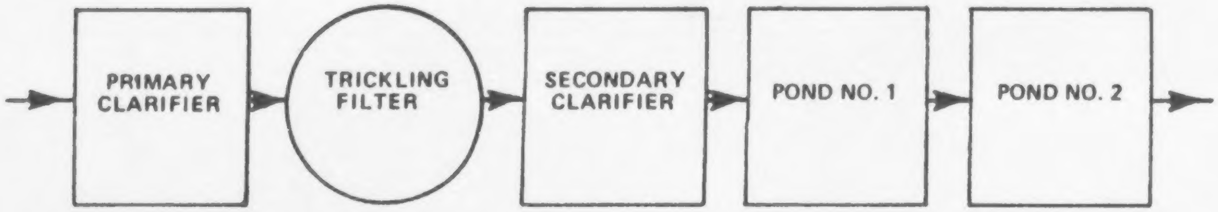
STABILIZATION PONDS IN SERIES


INFLUENT
RAW WASTE WATER
POND NO. 1
POND NO. 2
EFFLUENT

STABILIZATION PONDS IN PARALLEL


INFLUENT
PRIMARY CLARIFIER
POND NO. I
POND NO. 2
EFFLUENT

OXIDATION PONDS IN SERIES


PRIMARY CLARIFIER
TRICKLING FILTER
SECONDARY CLARIFIER
POND NO. 1
POND NO. 2

POLISHING PONDS IN SERIES

Fig. 26, Pond Classifications

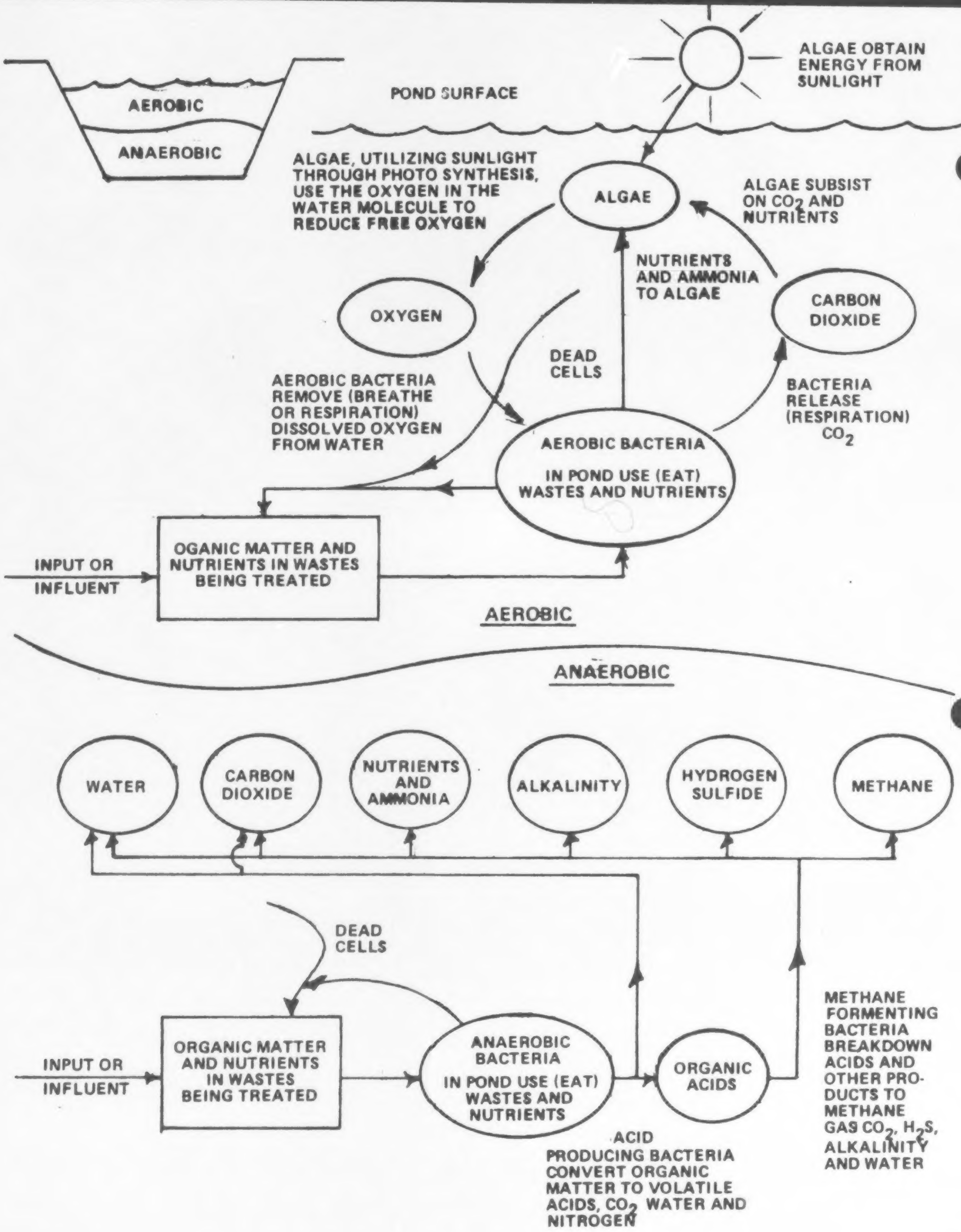

AEROBIC
ANAEROBIC
POND SURFACE
ALGAE OBTAIN ENERGY FROM SUNLIGHT
ALGAE, UTILIZING SUNLIGHT THROUGH PHOTO SYNTHESIS, USE THE OXYGEN IN THE WATER MOLECULE TO REDUCE FREE OXYGEN
ALGAE
ALGAE SUBSIST ON CO2 AND NUTRIENTS
NUTRIENTS AND AMMONIA TO ALGAE
OXYGEN
CARBON DIOXIDE
DEAD CELLS
AEROBIC BACTERIA REMOVE (BREATHE OR RESPIRATION) DISSOLVED OXYGEN FROM WATER
BACTERIA RELEASE (RESPIRATION) CO2
AEROBIC BACTERIA IN POND USE (EAT) WASTES AND NUTRIENTS
INPUT OR INFLUENT
OGANIC MATTER AND NUTRIENTS IN WASTES BEING TREATED
AEROBIC
ANAEROBIC
WATER
CARBON DIOXIDE
NUTRIENTS AND AMMONIA
ALKALINITY
HYDROGEN SULFIDE
METHANE
DEAD CELLS
INPUT OR INFLUENT
ORGANIC MATTER AND NUTRIENTS IN WASTES BEING TREATED
ANAEROBIC BACTERIA IN POND USE (EAT) WASTES AND NUTRIENTS
ORGANIC ACIDS
METHANE FORMENTING BACTERIA BREAKDOWN ACIDS AND OTHER PRODUCTS TO METHANE GAS CO2, H2S, ALKALINITY AND WATER
ACID PRODUCING BACTERIA CONVERT ORGANIC MATTER TO VOLATILE ACIDS, CO2 WATER AND NITROGEN

Fig. 27 Process of decomposition in aerobic and anaerobic layers of a pond

Week 13 Hour 2 Chapter: 9
Waste Treatment Ponds

Lesson Outline	Lecture Notes
Objectives: Refer to the objectives listed at the beginning of Chapter 9, Waste Treatment Ponds.	
Lecture Outline	
9.6 Starting the Pond	
1. Place one foot of water over bottom of pond before introducing wastewater	
2. If possible, start pond during warmer part of year	
3. Algae	
4. pH	
9.7 Daily Operation and Maintenance	
DO NOT NEGLECT A POND, DAILY OPERATIONAL AND MAINTENANCE DUTIES MUST BE PERFORMED	
1. Scum control	
2. Odor control	
3. Weed and insect control	
4. Levee maintenance	
5. Headworks and screening	
6. Operating hints	
7. Abnormal operation	
8. Batch operation	

Week 13 **Hour** 2 (Con'd) **Chapter:** 9
Waste Treatment Ponds

Lesson Outline

9. Shutting down a pond
10. Operating strategy

9.8 Surface Aerators

1. To provide additional air for ponds during the night or during cold weather, or for overloaded ponds.
2. To provide a mechanical aeration device for ponds operated as an aerated lagoon. Aerated lagoons operate similar to an activated sludge aeration tank without returning any settled activated sludge
3. Purpose of aerator components (Refer to Table 9.2, 2nd Ed.)

9.9 Sampling and Analysis

9.90 Importance

1. DO, pH, temperature
2. Color of pond

9.91 Frequency and location of lab samples (Refer to Table 9.3, 2nd Ed. frequency and location of lab samples)

1. Grab samples
2. Composite samples

Lecture Notes

Week 13 **Hour** 2 (Con'd) **Chapter:** 9
Waste Treatment Ponds

Lesson Outline	Lecture Notes
9.92 Expected treatment efficiencies 9.10 Safety 1. Slippery surfaces 2. Ventilate enclosed headworks 3. Working from a boat 4. Electrical hazards 5. Application of pesticides or herbicides 6. Fence area and provide warning signs	

Week 13 **Hour** 3 **Chapter:** 9
Waste Treatment Ponds

Lesson Outline	**Lecture Notes**
Objectives: Refer to the objectives listed at the beginning of Chapter 9, Waste Treatment Ponds.	

Lecture Outline

9.11 Review of Plans and Specifications

A careful review of the plans and specifications of a proposed pond can provide the operator an opportunity to suggest improvements and changes in design before construction which will allow the operator and the ponds to do a better job. Items to consider during review include:

1. Location
   a. Homes
   b. Wind directions
2. Chemistry of Wastes
   a. BOD
   b. Toxicants
   c. pH
3. Headworks and screening
4. Flow measuring devices
5. Inlet and outlet structures
6. Levees

Week 13 Hour 3 (Con'd) **Chapter:** 9
Waste Treatment Ponds

Lesson Outline | **Lecture Notes**

7. Pond depths

8. Fencing and signs

9. Surface aerators

10. Pond loading

    a. Detention time

$$\text{Detention time, days} = \frac{\text{Pond Volume, ac-ft}}{\text{Influent Rate, ac-ft/day}}$$

    b. Population loading

$$\text{No. of persons per acre} = \frac{\text{Population served, persons}}{\text{Area of Pond, ac.}}$$

    c. Hydraulic loading

$$\text{Inches per day} = \frac{\text{Inflow, ac-in per day}}{\text{Pond Area, ac.}}$$

or

$$\text{Inches per day} = \frac{\text{Pond Depth, in.}}{\text{Detention time, days}}$$

    d. Organic loading

$$\begin{array}{l}\text{Organic load,}\\ \text{lbs BOD per day}\\ \text{per acre}\end{array} = \frac{\text{Flow, MGD} \times \text{BOD, mg/l} \times 8.34\ \text{lbs/gal}}{\text{Pond Area, ac.}}$$

11. Example calculations

    a. Pond area, acres

    b. Pond volume, ac-ft

    c. Loading parameters

        1. Detention time

Week 13 **Hour** 3 (Con'd) **Chapter:** 9
Waste Treatment Ponds

Lesson Outline	**Lecture Notes**
2. Population loading 3. Hydraulic loading 4. Organic loading 9.12 Removal of Algae from Pond Effluents 1. Pond isolation 2. Water hyacinth culture	

Week 13 3-Hour Lab (Optional) Chapter: 9 Waste Treatment Ponds

Lesson Outline

Objective: Visit a waste treatment pond and observe or help (if possible) the operator operate and maintain the pond.

Lecture Notes

CHAPTER 10

DISINFECTION AND CHLORINATION

Week 14 **Hour** 1 **Chapter:** 10
Disinfection and Chlorination

Lesson Outline	**Lecture Notes**
Objectives: Refer to the objectives listed at the beginning of Chapter 10, Disinfection and Chlorination.	
Assignment: Discussion and review questions at the end of each lesson and the objective test at the end of Chapter 10.	
NOTE: Material on dechlorination may be omitted if sufficient time is not available.	
Lecture Outline	
Glossary: Review new words	
10.0 Need for disinfection	
10.00 Effectiveness in micro-organism removal by various treatment processes (Refer to Fig. 28)	
10.01 Disinfection	
1. Difference between disinfection and sterilization	
2. Public water supplies	
3. Receiving waters for recreational uses	
4. Shellfish growing areas	
10.02 Reaction of chlorine in wastewater	

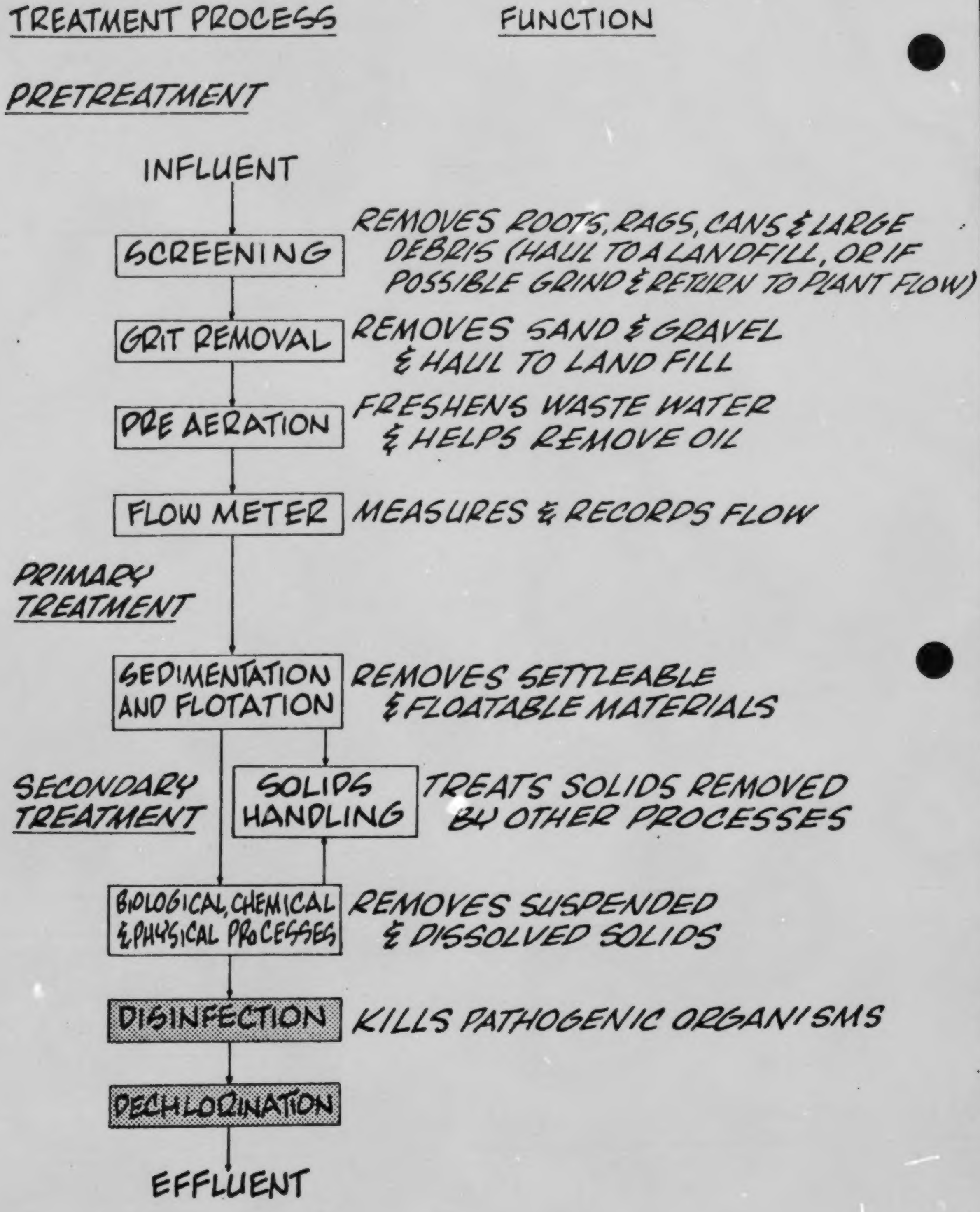

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
DECHLORINATION
EFFLUENT

Fig. 28

Week 14 Hour 1 (Con'd) Chapter: 10
Disinfection and Chlorination

Lesson Outline	Lecture Notes
10.03 Reactions of chlorine solutions with impurities in wastewater 1. Inorganic reducing materials 2. Reaction with ammonia (NH_3) 10.04 Hypochlorination of wastewater 10.05 Factors influencing disinfection 1. Injection point 2. Design (shape) of contact chamber 3. Contact time 4. Effectiveness of upstream treatment processes 5. Temperature 6. Dose rate and type of chemical 7. pH 10.06 Chlorine requirements	

Week 14 **Hour** 2 **Chapter:** 10 Disinfection and Chlorination

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of Chapter 10, Disinfection and Chlorination.

Lecture Outline

- 10.1 Points of Chlorine Application (Refer to Fig. 29)
  - 10.10 Collection system chlorination
  - 10.11 Prechlorination
  - 10.12 Plant chlorination
  - 10.13 Post chlorination
- 10.2 Chlorination Process Control
  - 10.20 Chlorinator control
    1. Manual control
    2. Start - stop control
    3. Step-rate control
    4. Time program control
    5. Flow proportional control
    6. Chlorine residual control
    7. Compound loop control
  - 10.21 Chlorination control nomogram
    1. How to use nomogram
    2. Work examples
  - 10.22 Hypochlorinator feed rate control
  - 10.23 Chlorine solution discharge

Lecture Notes

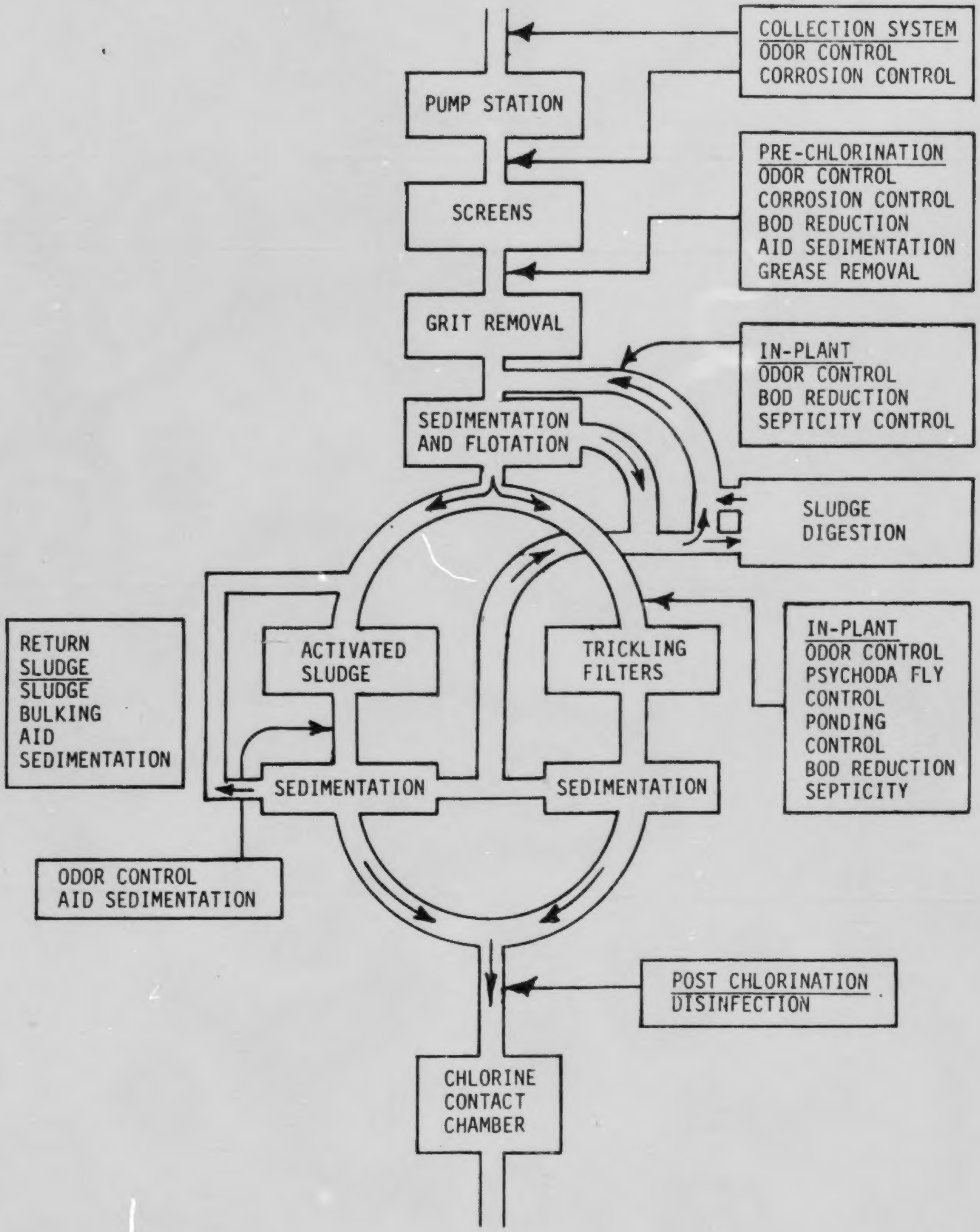

COLLECTION SYSTEM
ODOR CONTROL
CORROSION CONTROL
PUMP STATION
PRE-CHLORINATION
ODOR CONTROL
CORROSION CONTROL
BOD REDUCTION
AID SEDIMENTATION
GREASE REMOVAL
SCREENS
GRIT REMOVAL
IN-PLANT
ODOR CONTROL
BOD REDUCTION
SEPTICITY CONTROL
SEDIMENTATION AND FLOTATION
SLUDGE DIGESTION
RETURN SLUDGE
SLUDGE BULKING
AID SEDIMENTATION
ACTIVATED SLUDGE
TRICKLING FILTERS
IN-PLANT
ODOR CONTROL
PSYCHODA FLY CONTROL
PONDING CONTROL
BOD REDUCTION
SEPTICITY
SEDIMENTATION
SEDIMENTATION
ODOR CONTROL
AID SEDIMENTATION
POST CHLORINATION
DISINFECTION
CHLORINE CONTACT CHAMBER

Fig. 29, Points of chlorine application

Week 14 **Hour** 2 (Con'd) **Chapter:** 10
Disinfection and Chlorination

Lesson Outline	Lecture Notes
lines, diffusers, and mixing 1. Solution discharge lines 2. Chlorine solution diffusers 3. Mixing 10.24 Measurement of chlorine residual 10.25 Start up of chlorinators 1. Gas chlorinators 2. Liquid chlorine chlorinators 10.26 Normal and abnormal operation 1. Container storage area 2. Evaporators 3. No chlorine gas flow to the chlorinator (cylinder empty or icing) 4. Low chlorine residual 10.27 Shut down of a chlorinator 1. Short-term shut down 2. Long-term shut down 10.28 Operational strategy 1. Disinfection 2. Process control 3. Odor control 4. Dechlorination	

Week 14 **Hour** 2 (Con'd) **Chapter:** 10
Disinfection and Chlorination

Lesson Outline	**Lecture Notes**
5. Problems a. Run out of chlorine b. Failure of automatic control equipment c. Loss of injector vacuum d. Component failure 10.29 Chlorine Trouble-shooting Guide 1. Chlorine contact chamber 2. Chlorinator and evaporator 3. Chlorine supply system	

Week 14 **Hour** 3 **Chapter:** 10
Disinfection and Chlorination

Lesson Outline

Lecture Notes

Objectives: Refer to the objectives listed at the beginning of Chapter 10, Disinfection and Chlorination

Lecture Outline

10.3 Chlorine Safety Program

1. Establish a safety program
2. Written rules
3. Periodic hands-on training using safety equipment
4. Establish emergency procedures for chlorine leaks and first aid
5. Establish a maintenance and calibration program for safety devices and equipment

    10.30 Chlorine Hazards

    10.31 Why chlorine must be handled with care

    10.32 Protect yourself from chlorine

    10.33 First aid measures

10.4 Chlorine Handling

    10.40 Chlorine Containers

    1. Cylinders
    2. Ton tanks
    3. Chlorine tank cars

Week 14 **Hour** 3 (Con'd) **Chapter:** 10
Disinfection and Chlorination

Lesson Outline

10.41 Removing chloring from containers

1. Connections
2. Valves. Do not use wrenches longer than six inches to turn valves.
3. Ton tanks

10.42 Chlorine leaks

1. Before any new system is put into service
2. To find a chlorine leak
3. Equipment leak
4. Chlorine cylinder or container leak
5. Prolonged or unstoppable leak
6. Never put water on a chlorine leak
7. Leaks around valve stems
8. Valve discharge outlet leaks
9. Fusible plug and cylinder valve leaks

Lecture Notes

Week 14 Hour 3 (Con'd) **Chapter:** 10
Disinfection and Chlorination

Lesson Outline	Lecture Notes
10. Pin hole leaks 11. Do not ship leaking containers 12. Do not accept damaged or leaking containers 13. If a chlorine container develops a leak, be sure your supplier does not charge you for the unused chlorine. 14. Detection devices and alarm systems	

Week 14 3-Hour Lab (Optional) Chapter: 10 Disinfection and Chlorination

Lesson Outline	Lecture Notes
Objective: 1. Visit a wastewater or water treatment plant and observe or help (if possible) the operator operate and maintain a chlorinator. OR 2. Invite a representative from a chlorine manufacturer to discuss and demonstrate safe procedures for handling chlorine.	

Week 15 **Hour** 1 **Chapter:** 10
Disinfection and Chlorination

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of Chapter 10, Disinfection and Chlorination.

Assignment: Finish last week's assignment

Lecture Outline

10.5 Chlorination Equipment and Maintenance.

  10.50 Chlorinators

   1. Purpose: Put chlorine gas in a solution for application to the wastewater.
   2. Chlorinator components and purpose (Refer to Table 10.3, Second Edition)

  10.51 Evaporators

  10.52 Hypochlorinators

  10.53 Installation and maintenance

  10.54 Installation requirements

   1. Piping, valves and mainfolds
   2. Chlorinator injector water supply

10.6 Other Uses of Chlorine

Lecture Notes

Week 15 Hour 1 (Con'd) Chapter: 10
Disinfection and Chlorination

Lesson Outline

10.60 Odor control

10.61 Protection of Structures

10.62 Aid to treatment

1. Sedimentation and grease removal
2. Trickling filters
3. Activated sludge
4. Reduction of BOD

Lecture Notes

Week 15 **Hour** 2 **Chapter:**

Lesson Outline

Lecture Notes

Objective: Review for Exam III

1. Cover important material since last exam.
2. Emphasize purpose of processes, equipment and components.
3. Discuss start up, normal and abnormal operation, and shut down of processes and equipment.
4. Outline maintenance procedures.
5. Review safety hazards and safe procedures.
6. Identify important items that should be considered when reviewing plans and specifications.
7. Outline trouble-shooting procedures.

Week 15 Hour 3 Chapter:

Lesson Outline	Lecture Notes
Objective: Exam III	

Week 15 3 -**Hour** Lab (Optional) **Chapter:** 10
Disinfection and Chlorination

Lesson Outline

Objective: Learn how to use safety equipment.

1. Self-contained breathing apparatus
2. Gas detection devices
   - a. Toxic gases, hydrogen sulfide
   - b. Explosive conditions (Lower Explosive Limit)
   - c. Oxygen deficiency

Lecture Notes

Week 16 Hour 1 Chapter:

Lesson Outline	Lecture Notes
Objectives: 1. Review results of Exam III and correct all mistakes and errors. 2. Identify areas for future review and students who need additional help.	

Week 16 Hour 2 and 3 Chapter:

Lesson Outline	Lecture Notes
Objectives: 1. Cover any material not covered to date. 2. Review for final exam.	

Week 16 3-Hour Lab Chapter:
(Optional)

Lesson Outline	Lecture Notes
Suggest instructor select most appropriate lab activity for class.	

Week 17	Hour	Chapter:

Lesson Outline	Lecture Notes
Objective: Final Exam.	

IV SUGGESTED HANDOUT MATERIALS

I. Example Course Policy

1. Grading

Quizzes	100 points
Homework	100 points
3 Exams at 100 each	300 points
Final	200 points
TOTAL	700 points

Points are added at the end of the semester. All points are plotted on a scale from zero to 700.

Grades will be based on the breaks in the total points. (See attached typical distribution of grades).

2. Homework

Homework usually will be assigned at the beginning of the week.

All homework will be due at the end of the lab or the start of class the following week.

Late homework will be accepted until homework is returned.

Credit will not be given if homework is regularly turned in late or if homework is turned in after corrected homework is returned to the students.

3. Missed Exams

Make-up exams are not allowed.

If you miss an exam for a legitimate reason, your rank on other exams plus the final exam (counted twice) are averaged to determine rank and score on missed exam.

4. Examination Procedures

a. General. Follow instructions on exam.

(1) Arrive prepared with paper, pencils, straight edge and calculator. Be prepared to work any homework problem.

(2) Place name on examination sheet, otherwise do not write on exam.

(3) Write only on one side of paper used for writing exam solutions.

(4) Do not erase - instead line out errors.

(5) Circle all final answers.

(6) Begin examination when so instructed.

(7) Stop writing when so instructed.

(8) Do not talk or otherwise communicate with other examinees. You will lose 5 points the first time you look at another paper or talk to anyone. You will lose 10 points the second time, 20 points the third, 40 points the fourth time, etc.

(9) If you have a question regarding the examination after it is in progress,raise your hand.

5. Old Exams

Old exams are available for review from the instructor's secretary,

6. Examination Critique

a. Examine your solutions to ascertain that they have all been graded. If a problem has been overlooked, it should be mentioned to the instructor prior to the commencement of the critique.

b. The examination critique is a part of the instructional process. You are expected to attend.

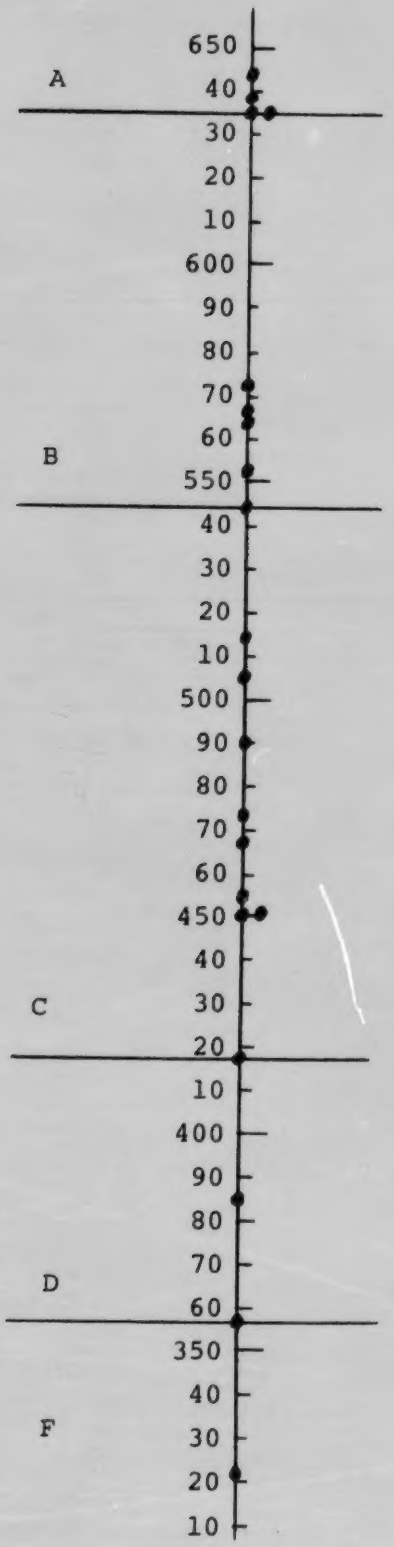
7. Dropping Course

Students will be allowed to drop until one week after the first exam. You will not be allowed to drop at the end of the semester if you are failing the course due to poor grades, failure to hand in homework, or enrolled in too heavy a load. You may drop with a valid excuse at any time. (Should be in accordance with school policy).

8. Final Grade

To obtain your grade at the end of the semester, leave a self-addressed stamped post card or envelope with the instructor at the final exam. Grades will not be posted.

TYPICAL DISTIBUTION OF GRADES



3. OPERATOR CERTIFICATION INFORMATION

Write

Mr. Robert V. Daigh, Chief
Operator Certification Office
State Water Resources Control Board
P. O. Box 100
Sacramento, California 95801

OR

Phone (916) 322-4140

to obtain handout material and the most recent available information regarding operator certification.

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V TRANSPARENCY MATERIALS

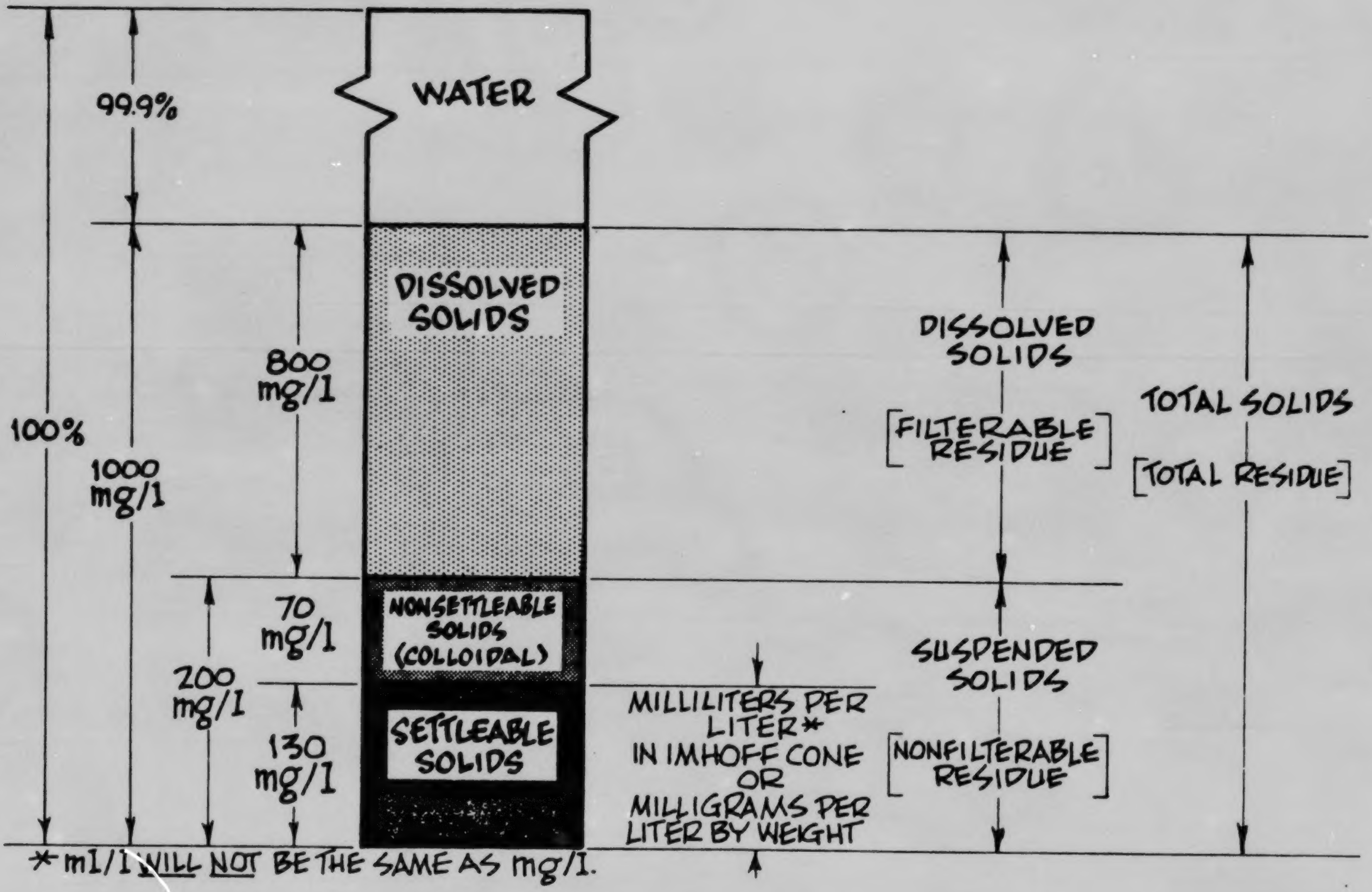
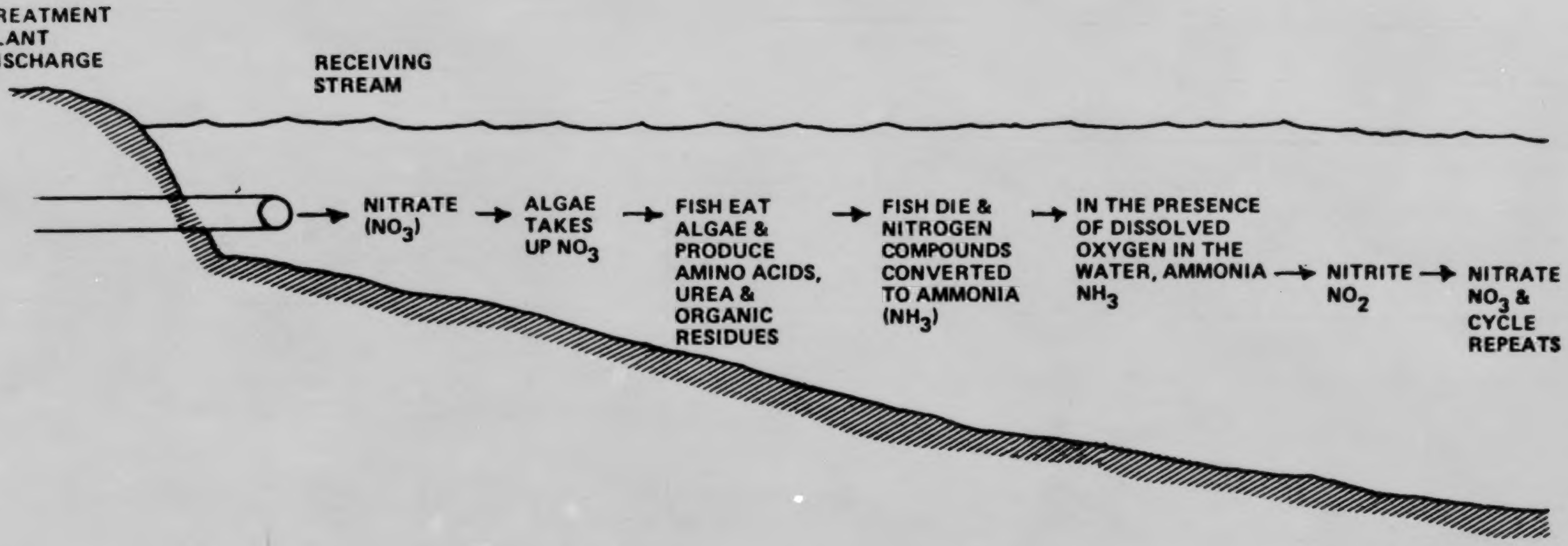

WATER
99.9%
100%
1000 mg/l
DISSOLVED SOLIDS
800 mg/l
NONSETTLEABLE SOLIDS (COLLOIDAL)
70 mg/l
200 mg/l
SETTLEABLE SOLIDS
130 mg/l
MILLILITERS PER LITER* IN IMHOFF CONE OR MILLIGRAMS PER LITER BY WEIGHT
DISSOLVED SOLIDS
[FILTERABLE RESIDUE]
SUSPENDED SOLIDS
[NONFILTERABLE RESIDUE]
TOTAL SOLIDS
[TOTAL RESIDUE]
* ml/l WILL NOT BE THE SAME AS mg/l.

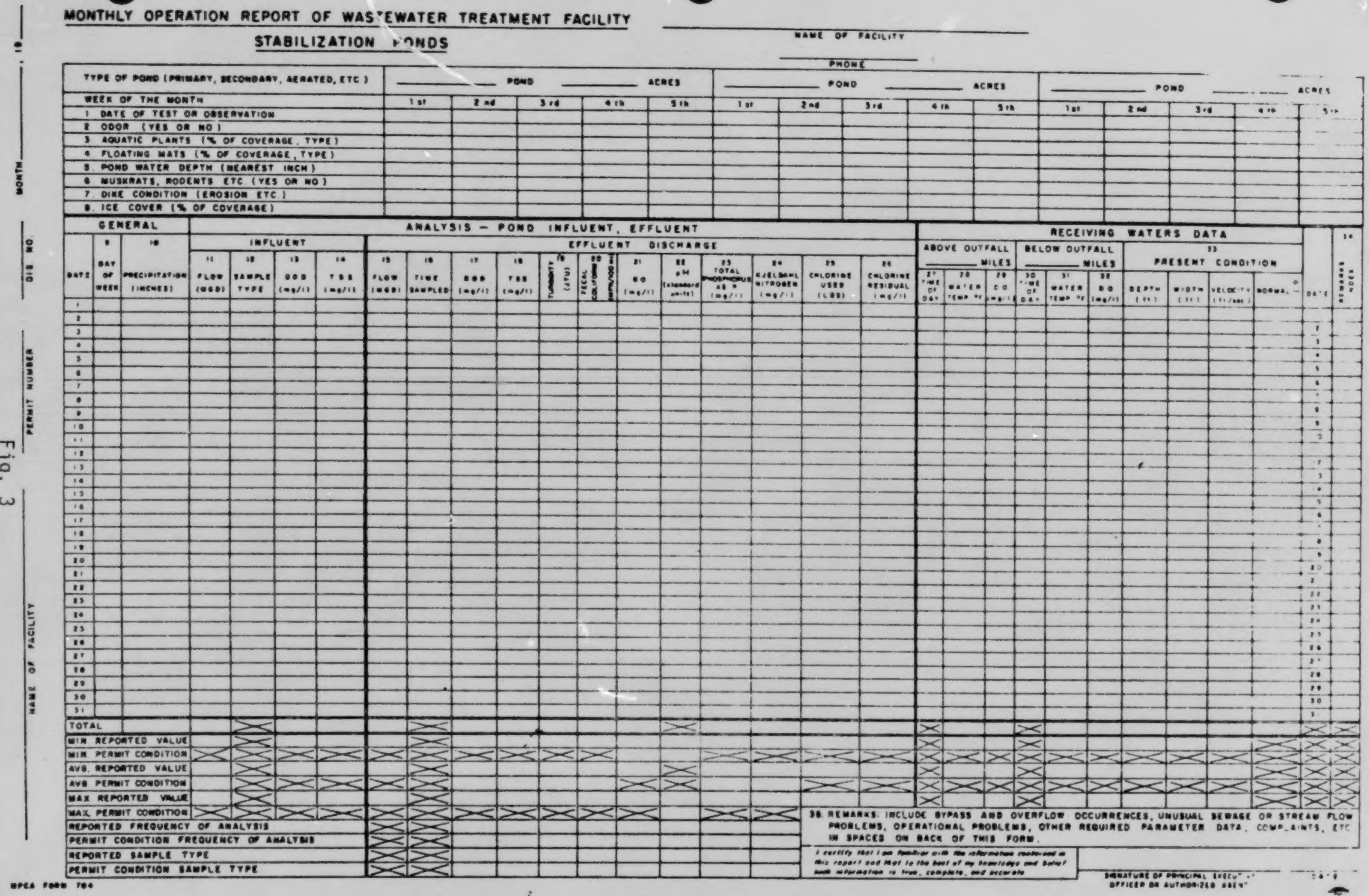
Fig. 1

Composition of solids in raw wastewater

Fig. 2
176


TREATMENT PLANT DISCHARGE
RECEIVING STREAM
NITRATE (NO_3)
ALGAE TAKES UP NO_3
FISH EAT ALGAE & PRODUCE AMINO ACIDS, UREA & ORGANIC RESIDUES
FISH DIE & NITROGEN COMPOUNDS CONVERTED TO AMMONIA (NH_3)
IN THE PRESENCE OF DISSOLVED OXYGEN IN THE WATER, AMMONIA NH_3
NITRITE NO_2
NITRATE NO_3 & CYCLE REPEATS

Simplified illus[illegible]tion of nitrogen cycle



MONTH ______, 19__

DIS. NO.

PERMIT NUMBER

NAME OF FACILITY

MONTHLY OPERATION REPORT OF WASTEWATER TREATMENT FACILITY

STABILIZATION PONDS

______________________ NAME OF FACILITY

______________________ PHONE

TYPE OF POND (PRIMARY, SECONDARY, AERATED, ETC.)	______ POND ______ ACRES					______ POND ______ ACRES					______ POND ______ ACRES				
WEEK OF THE MONTH	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
1 DATE OF TEST OR OBSERVATION															
2 ODOR (YES OR NO)															
3 AQUATIC PLANTS (% OF COVERAGE, TYPE)															
4 FLOATING MATS (% OF COVERAGE, TYPE)															
5. POND WATER DEPTH (NEAREST INCH)															
6 MUSKRATS, RODENTS ETC. (YES OR NO)															
7. DIKE CONDITION (EROSION ETC.)															
8. ICE COVER (% OF COVERAGE)															

GENERAL			ANALYSIS – POND INFLUENT, EFFLUENT															
			INFLUENT				EFFLUENT DISCHARGE											
DATE	9 DAY OF WEEK	10 PRECIPITATION (INCHES)	11 FLOW (MGD)	12 SAMPLE TYPE	13 BOD (mg/l)	14 TSS (mg/l)	15 FLOW (MGD)	16 TIME SAMPLED	17 BOD (mg/l)	18 TSS (mg/l)	19 TURBIDITY (JTU)	20 FECAL COLIFORM MPN/100ml	21 DO (mg/l)	22 pH (standard units)	23 TOTAL PHOSPHORUS AS P (mg/l)	24 KJELDAHL NITROGEN (mg/l)	25 CHLORINE USED (LBS)	26 CHLORINE RESIDUAL (mg/l)
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
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22																		
23																		
24																		
25																		
26																		
27																		
28																		
29																		
30																		
31																		
TOTAL				X				X						X				
MIN. REPORTED VALUE				X				X										
MIN. PERMIT CONDITION			X	X	X	X	X	X	X	X	X	X			X	X	X	X
AVG. REPORTED VALUE				X				X						X				
AVG. PERMIT CONDITION				X	X	X	X	X					X	X			X	X
MAX. REPORTED VALUE				X				X										
MAX. PERMIT CONDITION			X	X	X	X	X	X	X	X	X	X	X		X	X		
REPORTED FREQUENCY OF ANALYSIS							X	X										
PERMIT CONDITION FREQUENCY OF ANALYSIS							X	X										
REPORTED SAMPLE TYPE							X	X										
PERMIT CONDITION SAMPLE TYPE							X	X										

	RECEIVING WATERS DATA											
	ABOVE OUTFALL ______ MILES			BELOW OUTFALL ______ MILES			33 PRESENT CONDITION					
DATE	27 TIME OF DAY	28 WATER TEMP °F	29 DO (mg/l)	30 TIME OF DAY	31 WATER TEMP °F	32 DO (mg/l)	DEPTH (ft)	WIDTH (ft)	VELOCITY (ft/sec)	NORMAL	DATE	34 [illegible]
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
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20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												
TOTAL	X			X							X	X
MIN. REPORTED VALUE	X			X						X	X	X
MIN. PERMIT CONDITION	X	X	X	X	X	X	X	X	X	X	X	X
AVG. REPORTED VALUE	X			X						X	X	X
AVG. PERMIT CONDITION	X	X	X	X	X	X	X	X	X	X	X	X
MAX. REPORTED VALUE	X			X						X	X	X

35. REMARKS: INCLUDE BYPASS AND OVERFLOW OCCURRENCES, UNUSUAL SEWAGE OR STREAM FLOW PROBLEMS, OPERATIONAL PROBLEMS, OTHER REQUIRED PARAMETER DATA, COMPLAINTS, ETC IN SPACES ON BACK OF THIS FORM.

I certify that I am familiar with the information contained in this report and that to the best of my knowledge and belief such information is true, complete, and accurate

______________________ SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT

______ DATE

NPCA FORM 704

Fig. 3

Typical NPDES permit

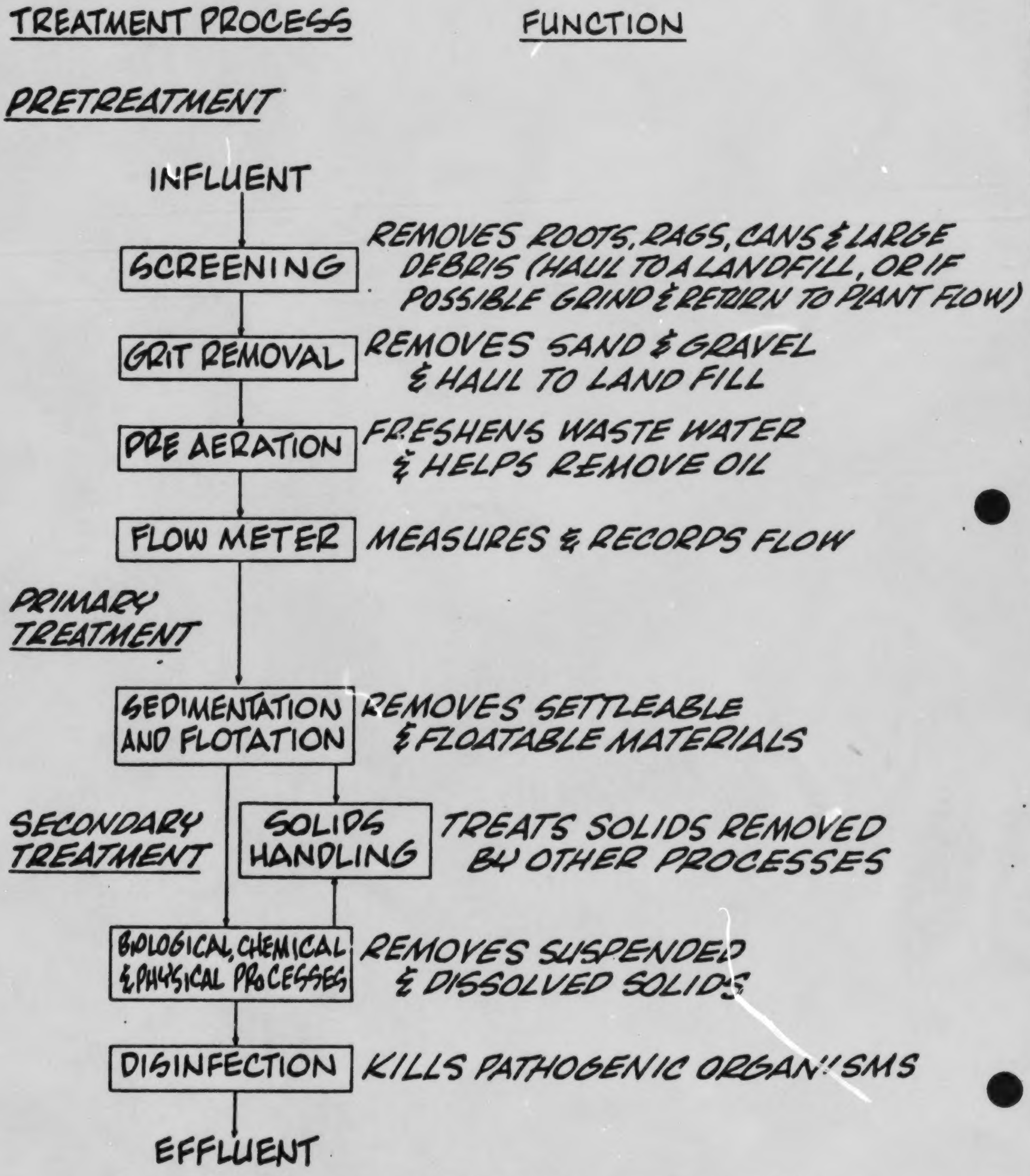
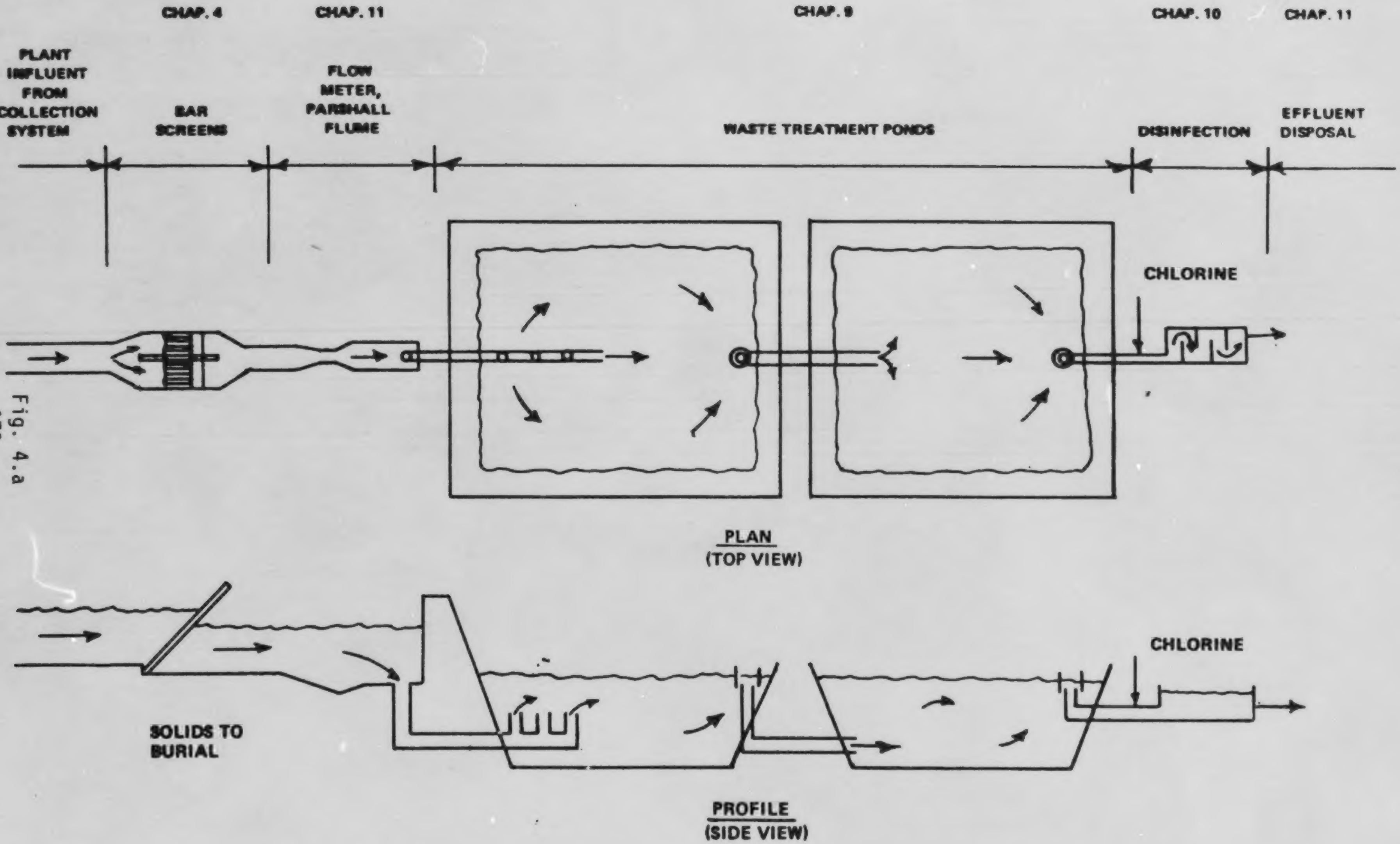

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETIRN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

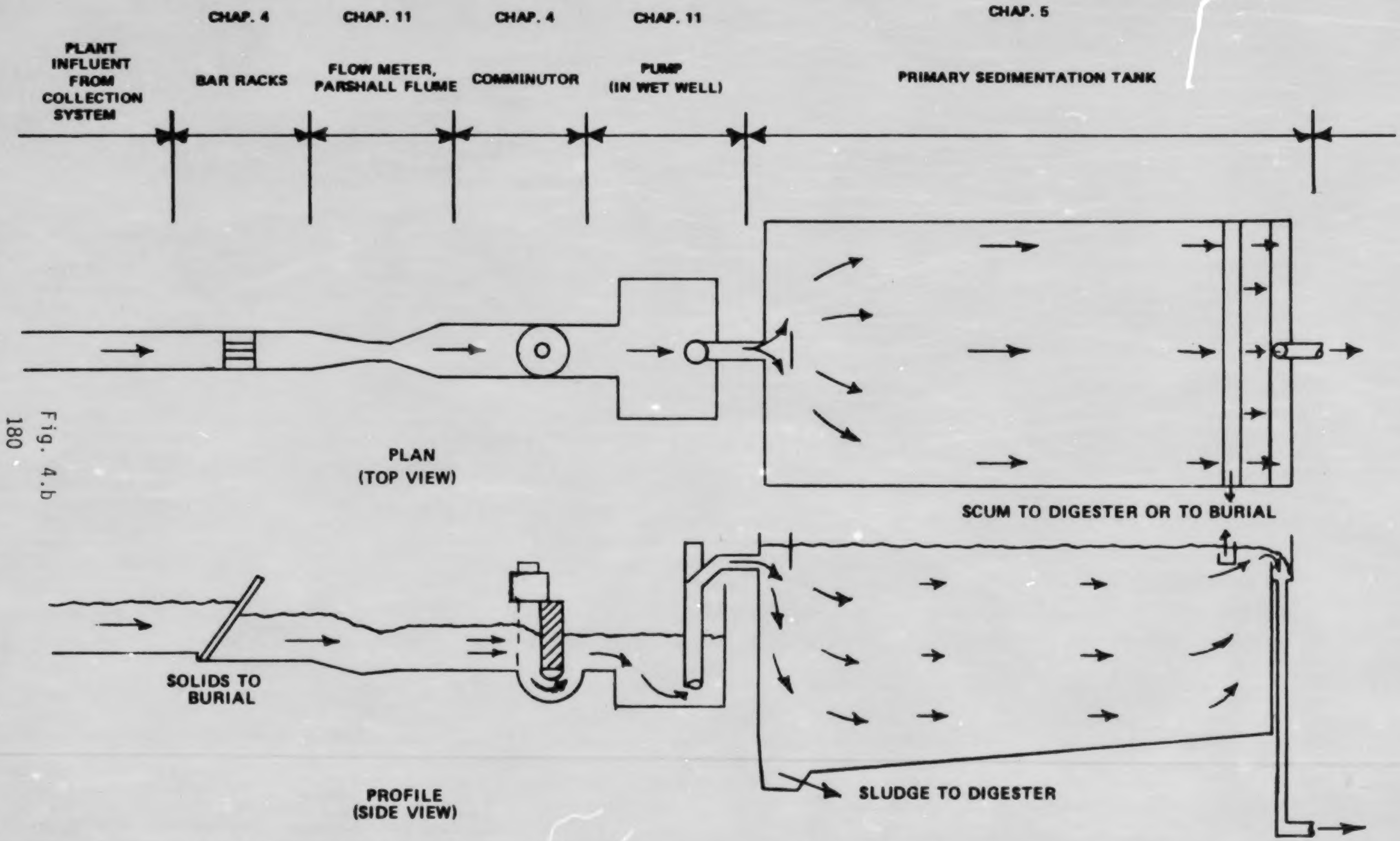
Fig. 4 Flow Diagram of Wastewater Treatment Processes

Fig. 4.a
179


CHAP. 4
CHAP. 11
CHAP. 9
CHAP. 10
CHAP. 11
PLANT INFLUENT FROM COLLECTION SYSTEM
BAR SCREENS
FLOW METER, PARSHALL FLUME
WASTE TREATMENT PONDS
DISINFECTION
EFFLUENT DISPOSAL
CHLORINE
PLAN
(TOP VIEW)
CHLORINE
SOLIDS TO BURIAL
PROFILE
(SIDE VIEW)

Possible flow pattern through a pond treatment plant

Fig. 4.b
180


CHAP. 4
CHAP. 11
CHAP. 4
CHAP. 11
CHAP. 5
PLANT INFLUENT FROM COLLECTION SYSTEM
BAR RACKS
FLOW METER, PARSHALL FLUME
COMMINUTOR
PUMP (IN WET WELL)
PRIMARY SEDIMENTATION TANK
PLAN (TOP VIEW)
SCUM TO DIGESTER OR TO BURIAL
SOLIDS TO BURIAL
SLUDGE TO DIGESTER
PROFILE (SIDE VIEW)

NOTE: SOLIDS FLOW NOT SHOWN, SEE SECTION 3.7

Possible flow pattern through a trickling filter plant

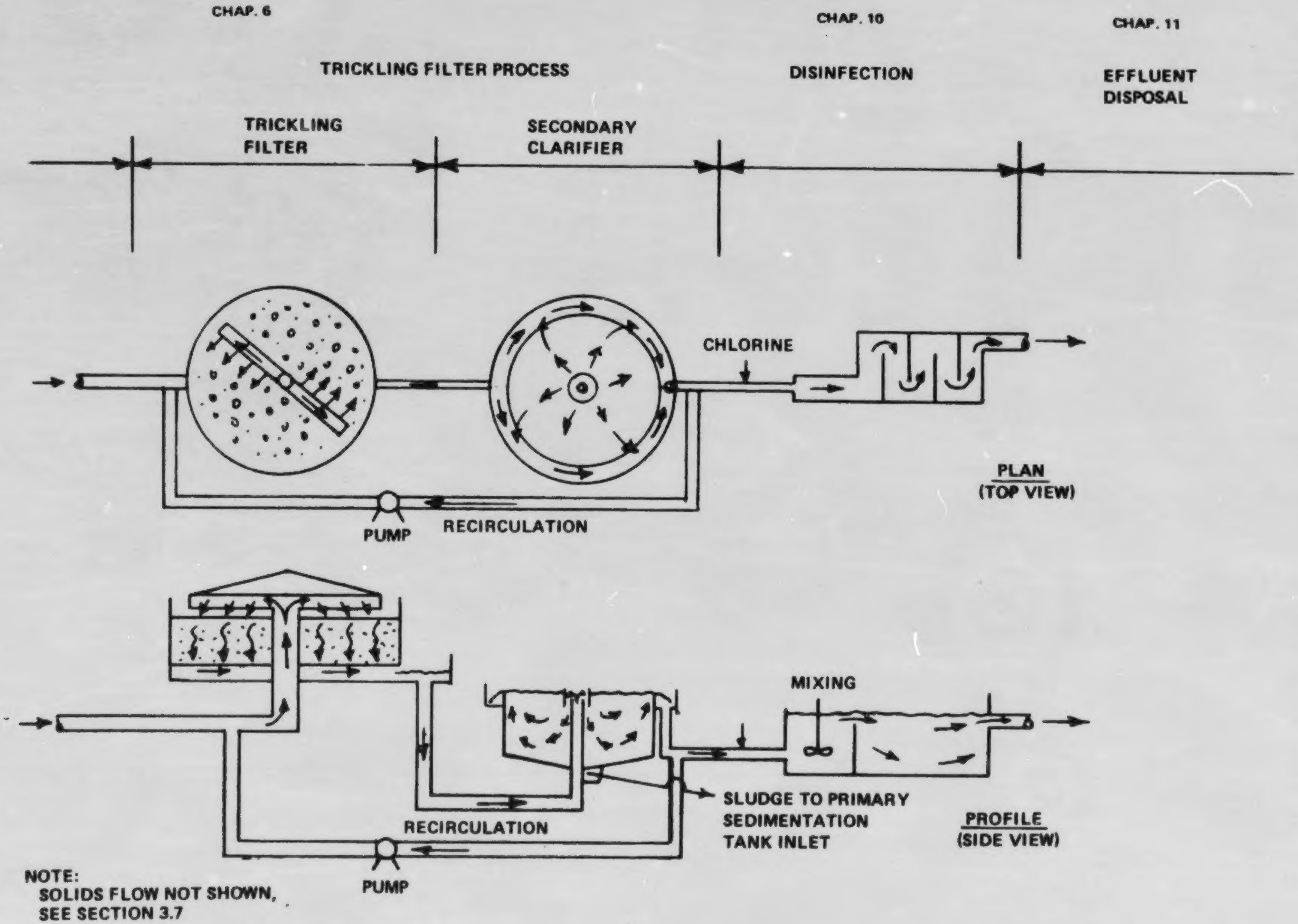
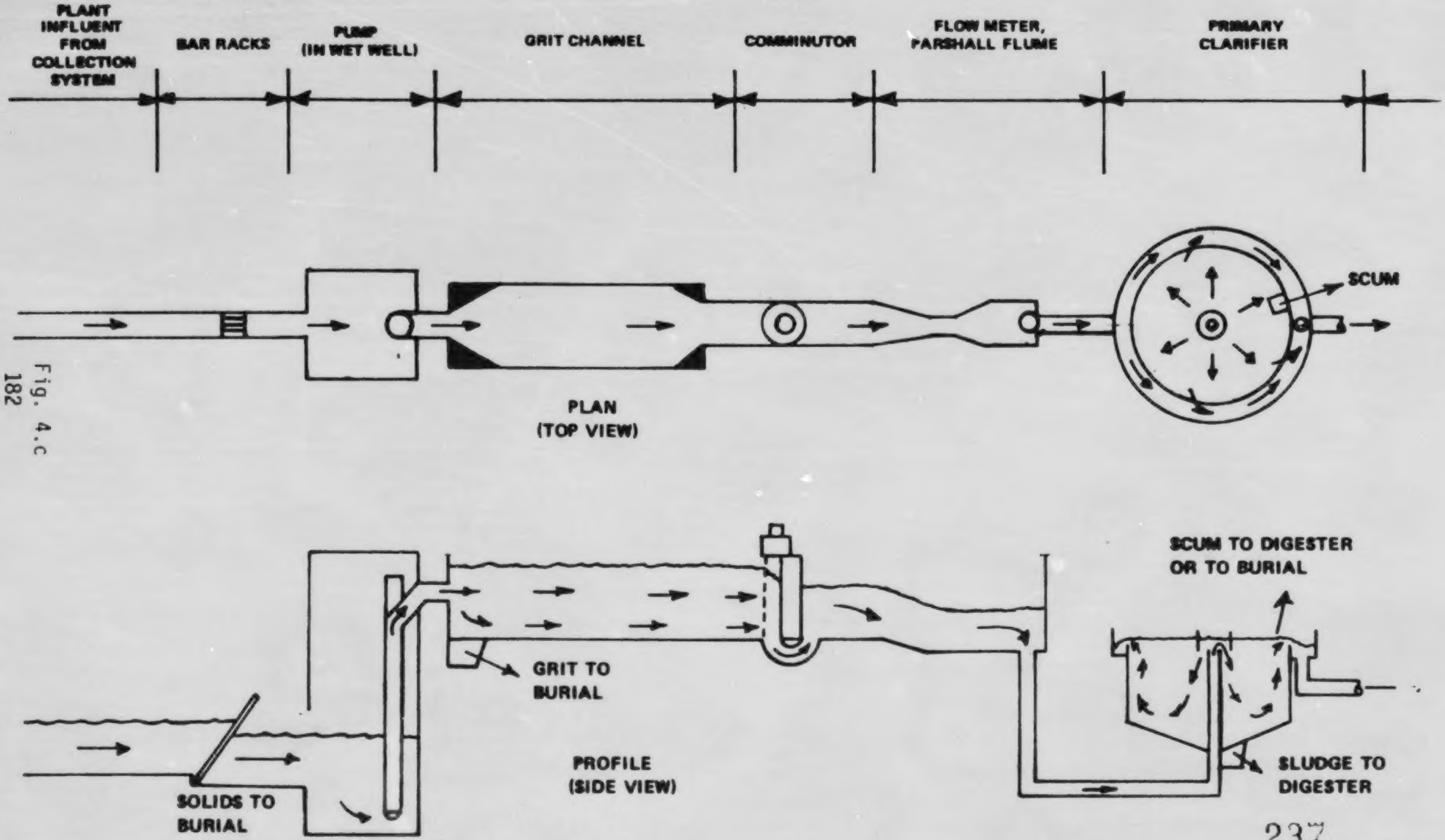

CHAP. 6
TRICKLING FILTER PROCESS
CHAP. 10
DISINFECTION
CHAP. 11
EFFLUENT DISPOSAL
TRICKLING FILTER
SECONDARY CLARIFIER
CHLORINE
PLAN (TOP VIEW)
PUMP
RECIRCULATION
MIXING
SLUDGE TO PRIMARY SEDIMENTATION TANK INLET
PROFILE (SIDE VIEW)
RECIRCULATION
PUMP
NOTE: SOLIDS FLOW NOT SHOWN, SEE SECTION 3.7

Fig. 4.b (Con'd)
181

(Con'd) Possible flow pattern through a trickling filter plant

Fig. 4.c
182



CHAP. 4
CHAP. 11
CHAP. 4
CHAP. 4
CHAP. 11
CHAP. 5
PLANT INFLUENT FROM COLLECTION SYSTEM
BAR RACKS
PUMP (IN WET WELL)
GRIT CHANNEL
COMMINUTOR
FLOW METER, PARSHALL FLUME
PRIMARY CLARIFIER
SCUM
PLAN (TOP VIEW)
SCUM TO DIGESTER OR TO BURIAL
GRIT TO BURIAL
SOLIDS TO BURIAL
PROFILE (SIDE VIEW)
SLUDGE TO DIGESTER

NOTE: SOLIDS FLOW NOW SHOWN, SEE SECTION 3.7

Possible flow pattern through an activated sludge plant

7

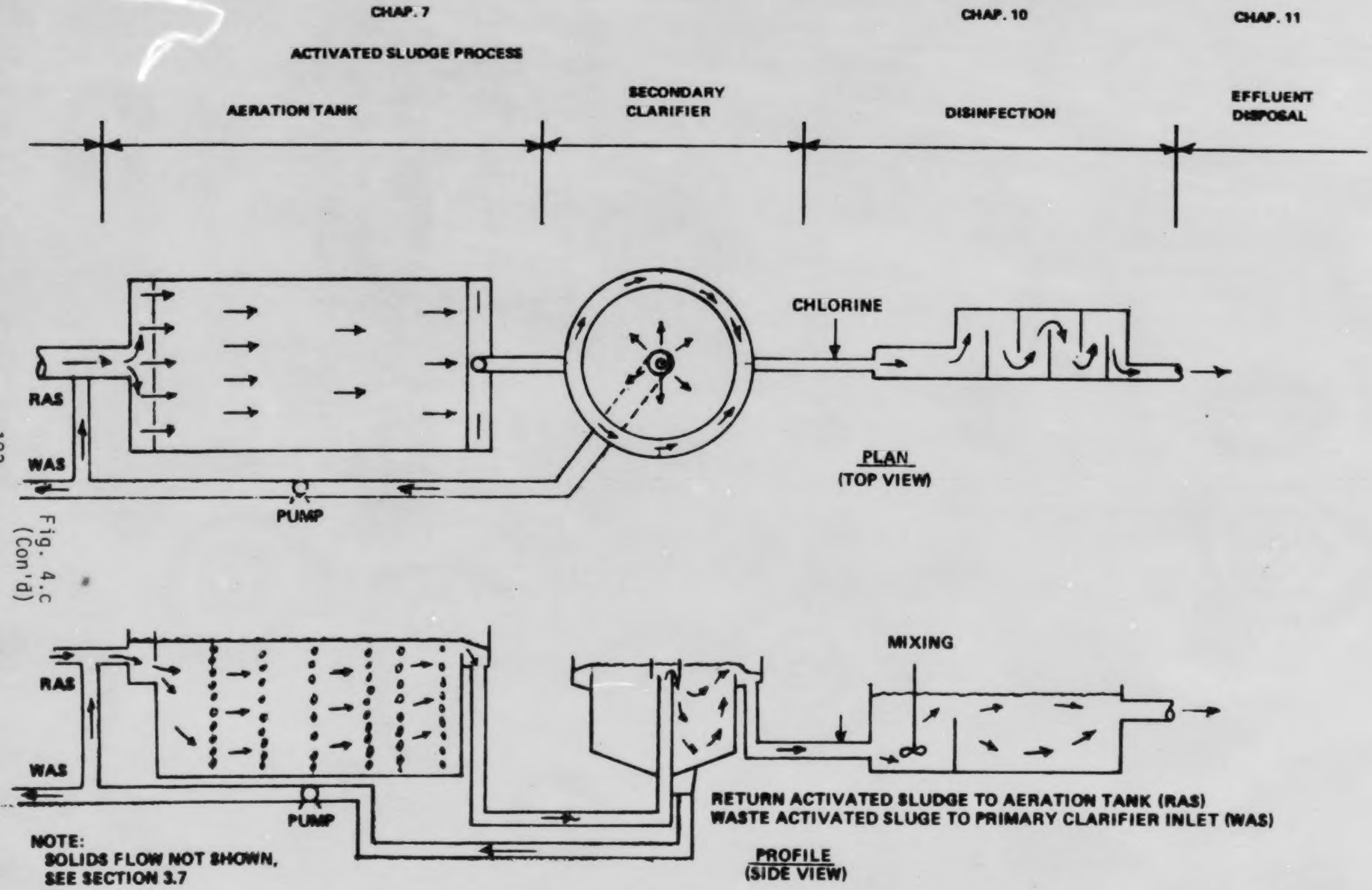
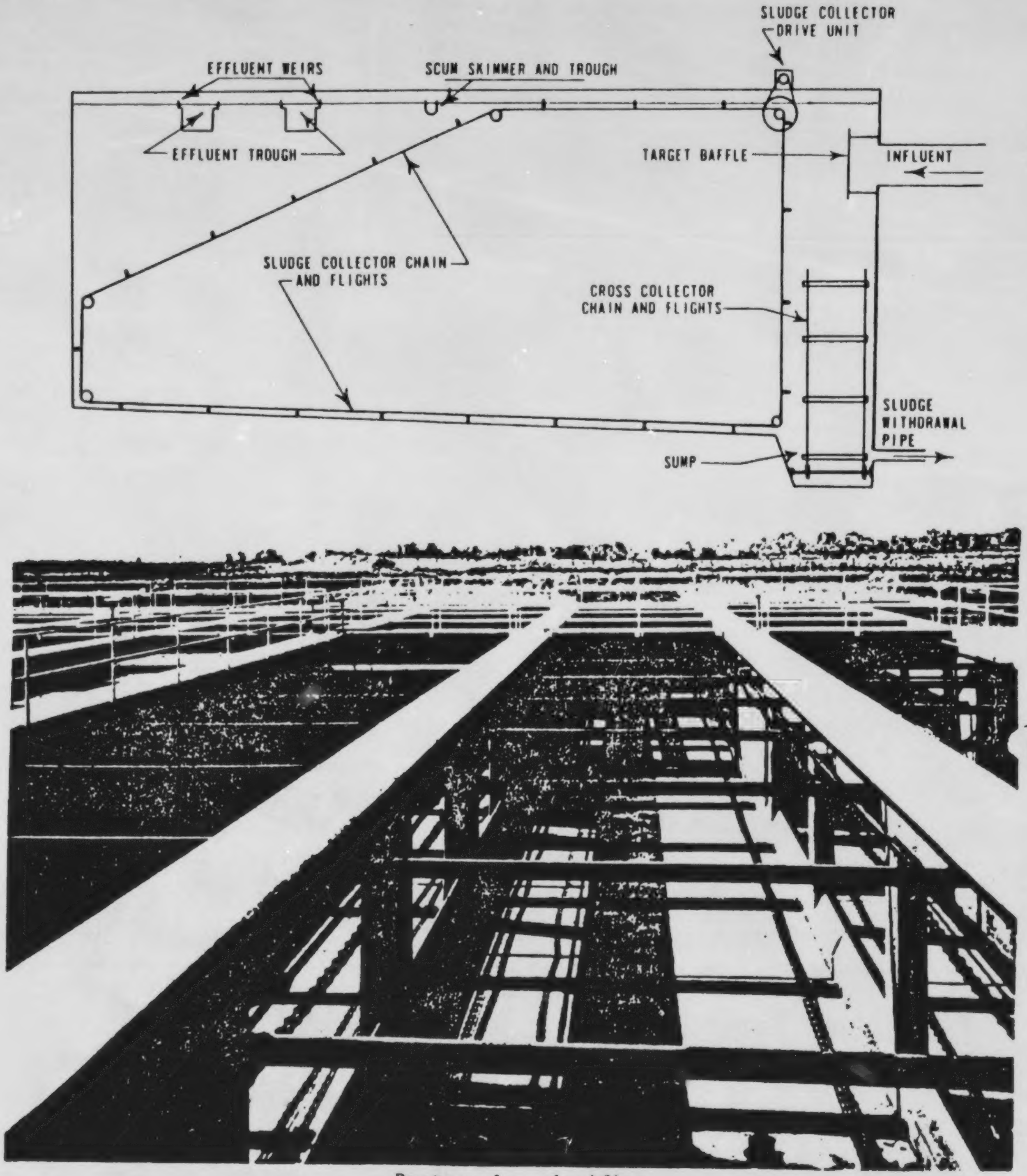

CHAP. 7
ACTIVATED SLUDGE PROCESS
CHAP. 10
CHAP. 11
AERATION TANK
SECONDARY CLARIFIER
DISINFECTION
EFFLUENT DISPOSAL
CHLORINE
RAS
WAS
PUMP
PLAN
(TOP VIEW)
MIXING
RAS
WAS
PUMP
RETURN ACTIVATED SLUDGE TO AERATION TANK (RAS)
WASTE ACTIVATED SLUGE TO PRIMARY CLARIFIER INLET (WAS)
NOTE:
SOLIDS FLOW NOT SHOWN,
SEE SECTION 3.7
PROFILE
(SIDE VIEW)

Fig. 4.c
(Con'd)

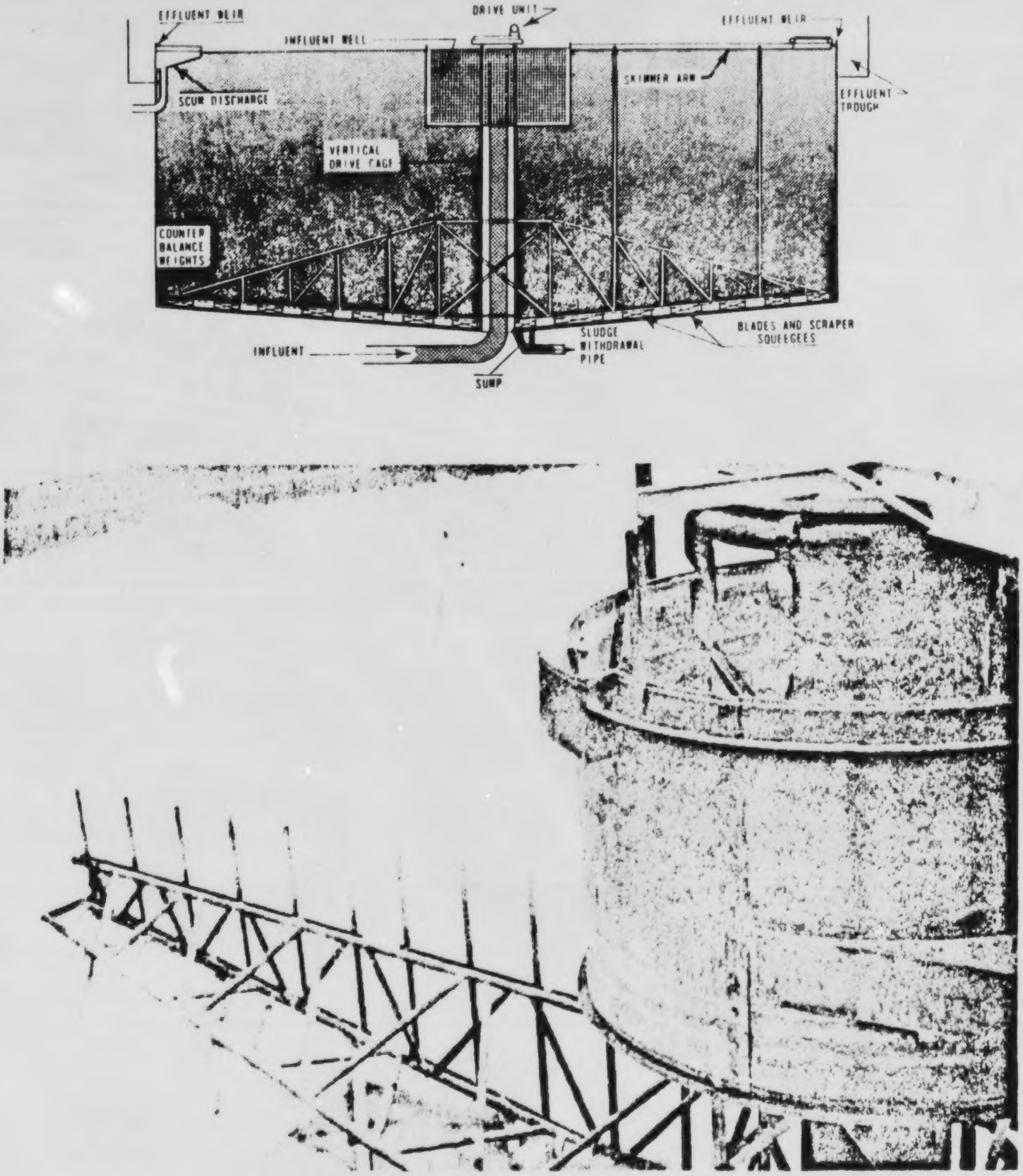
(Con'd) Possible flow patterns through an activated sludge plant


SLUDGE COLLECTOR DRIVE UNIT
EFFLUENT WEIRS
SCUM SKIMMER AND TROUGH
EFFLUENT TROUGH
TARGET BAFFLE
INFLUENT
SLUDGE COLLECTOR CHAIN AND FLIGHTS
CROSS COLLECTOR CHAIN AND FLIGHTS
SLUDGE WITHDRAWAL PIPE
SUMP

Rectangular clarifier

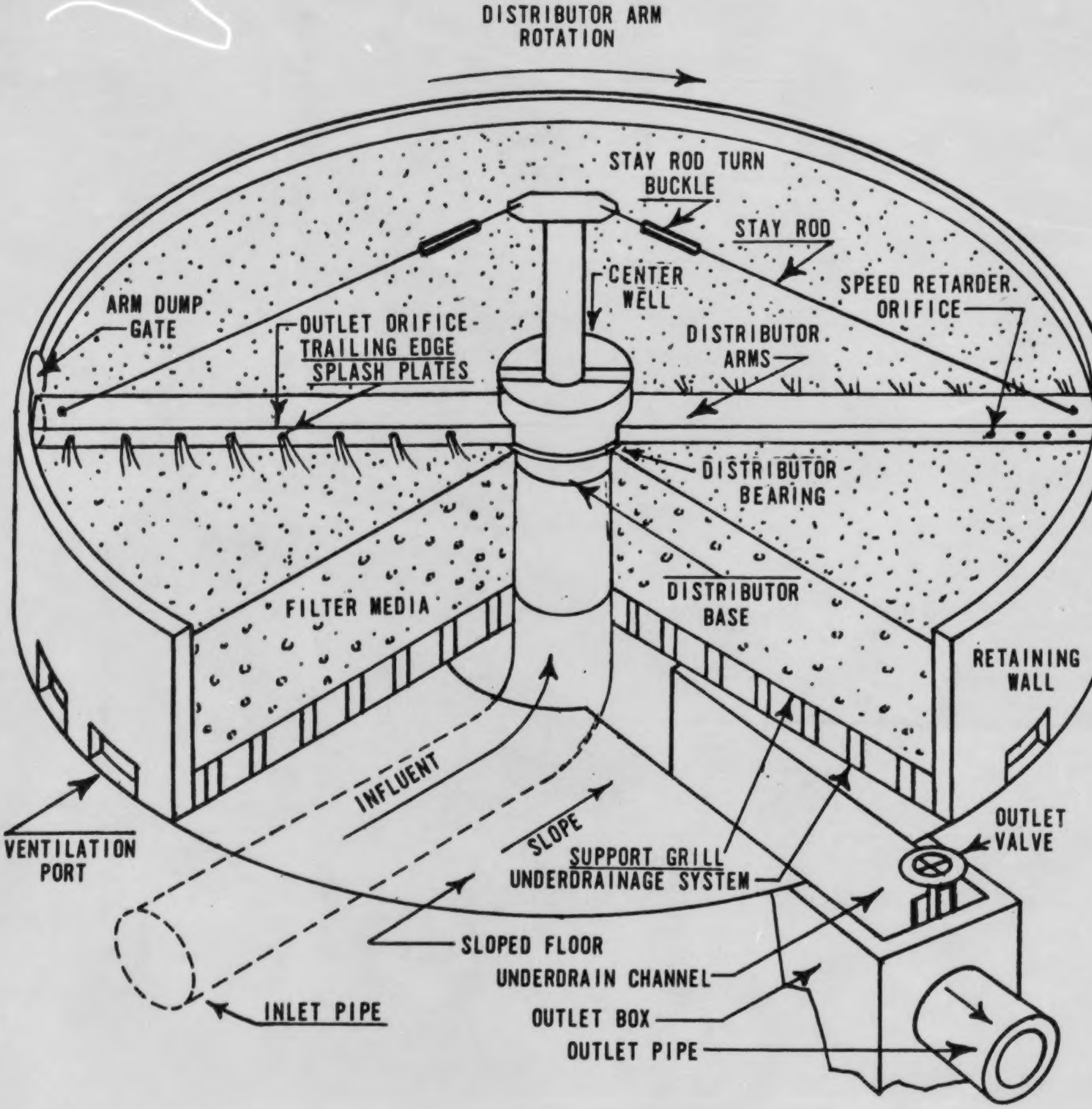
(Courtesy Jeffrey)

Fig. 5


EFFLUENT WEIR
INFLUENT WELL
DRIVE UNIT
EFFLUENT WEIR
SKIMMER ARM
EFFLUENT TROUGH
SCUM DISCHARGE
VERTICAL DRIVE CAGE
COUNTER BALANCE WEIGHTS
INFLUENT
SUMP
SLUDGE WITHDRAWAL PIPE
BLADES AND SCRAPER SQUEEGEES

Circular clarifier

Fig. 6


DISTRIBUTOR ARM ROTATION
STAY ROD TURN BUCKLE
STAY ROD
CENTER WELL
SPEED RETARDER ORIFICE
ARM DUMP GATE
OUTLET ORIFICE
TRAILING EDGE SPLASH PLATES
DISTRIBUTOR ARMS
DISTRIBUTOR BEARING
FILTER MEDIA
DISTRIBUTOR BASE
RETAINING WALL
INFLUENT
SLOPE
OUTLET VALVE
VENTILATION PORT
SUPPORT GRILL
UNDERDRAINAGE SYSTEM
SLOPED FLOOR
UNDERDRAIN CHANNEL
INLET PIPE
OUTLET BOX
OUTLET PIPE

Trickling filter

Fig. 7 242

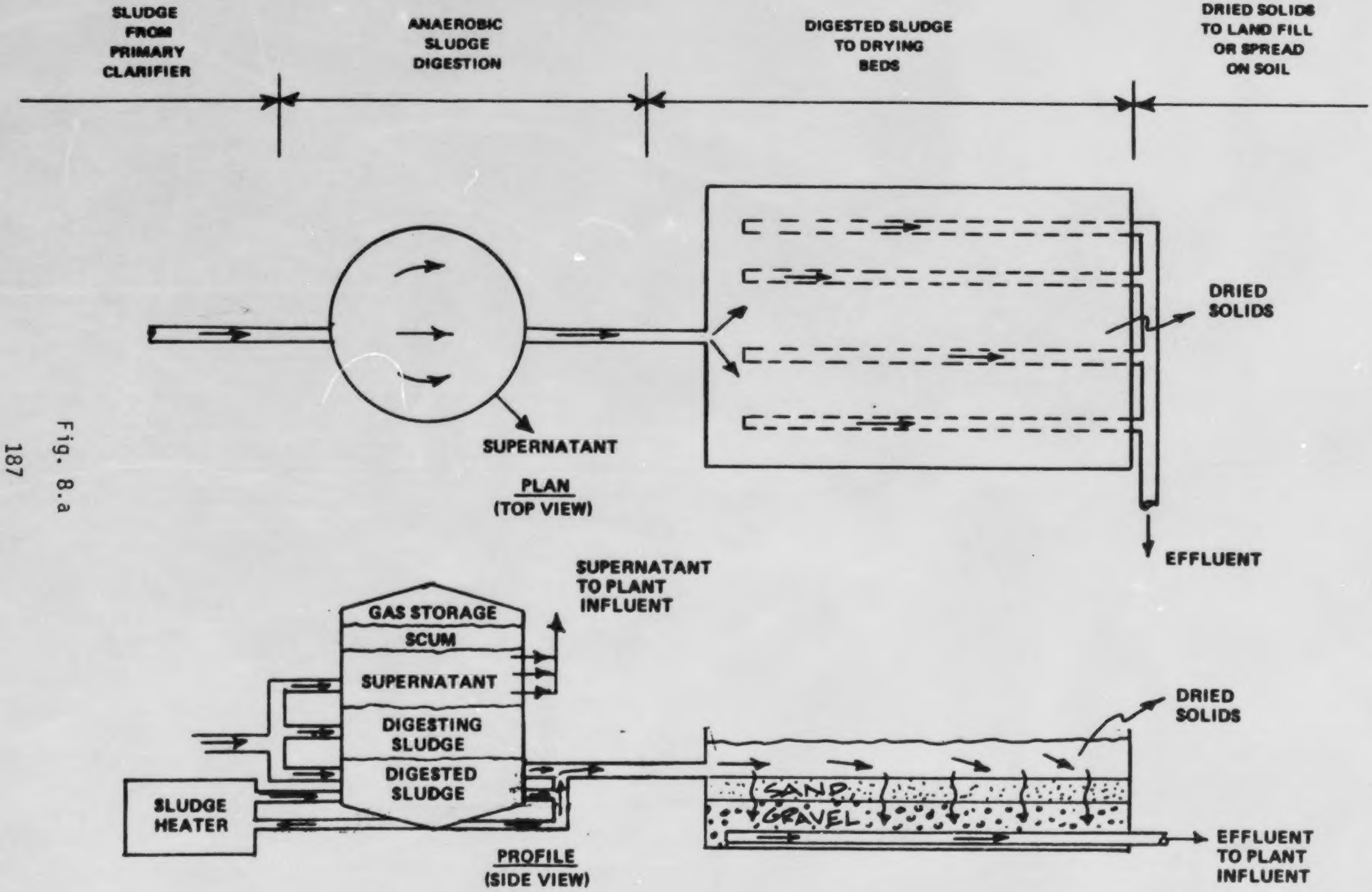

SLUDGE FROM PRIMARY CLARIFIER
ANAEROBIC SLUDGE DIGESTION
DIGESTED SLUDGE TO DRYING BEDS
DRIED SOLIDS TO LAND FILL OR SPREAD ON SOIL
DRIED SOLIDS
SUPERNATANT
PLAN
(TOP VIEW)
EFFLUENT
SUPERNATANT TO PLANT INFLUENT
GAS STORAGE
SCUM
SUPERNATANT
DIGESTING SLUDGE
DIGESTED SLUDGE
SLUDGE HEATER
DRIED SOLIDS
SAND
GRAVEL
EFFLUENT TO PLANT INFLUENT
PROFILE
(SIDE VIEW)

Fig. 8.a

Possible sludge processing and solids disposal flow pattern (sludge drying beds)

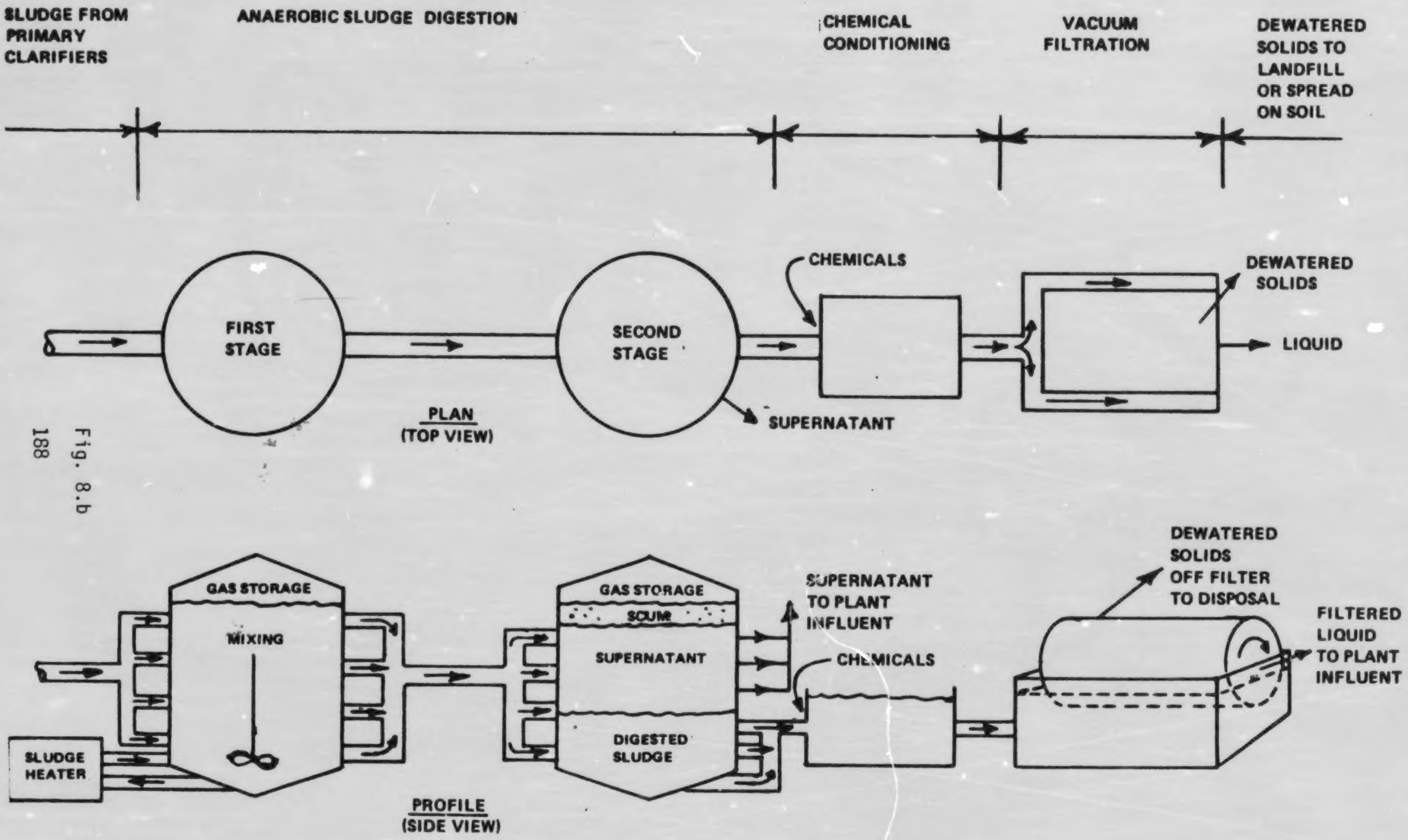
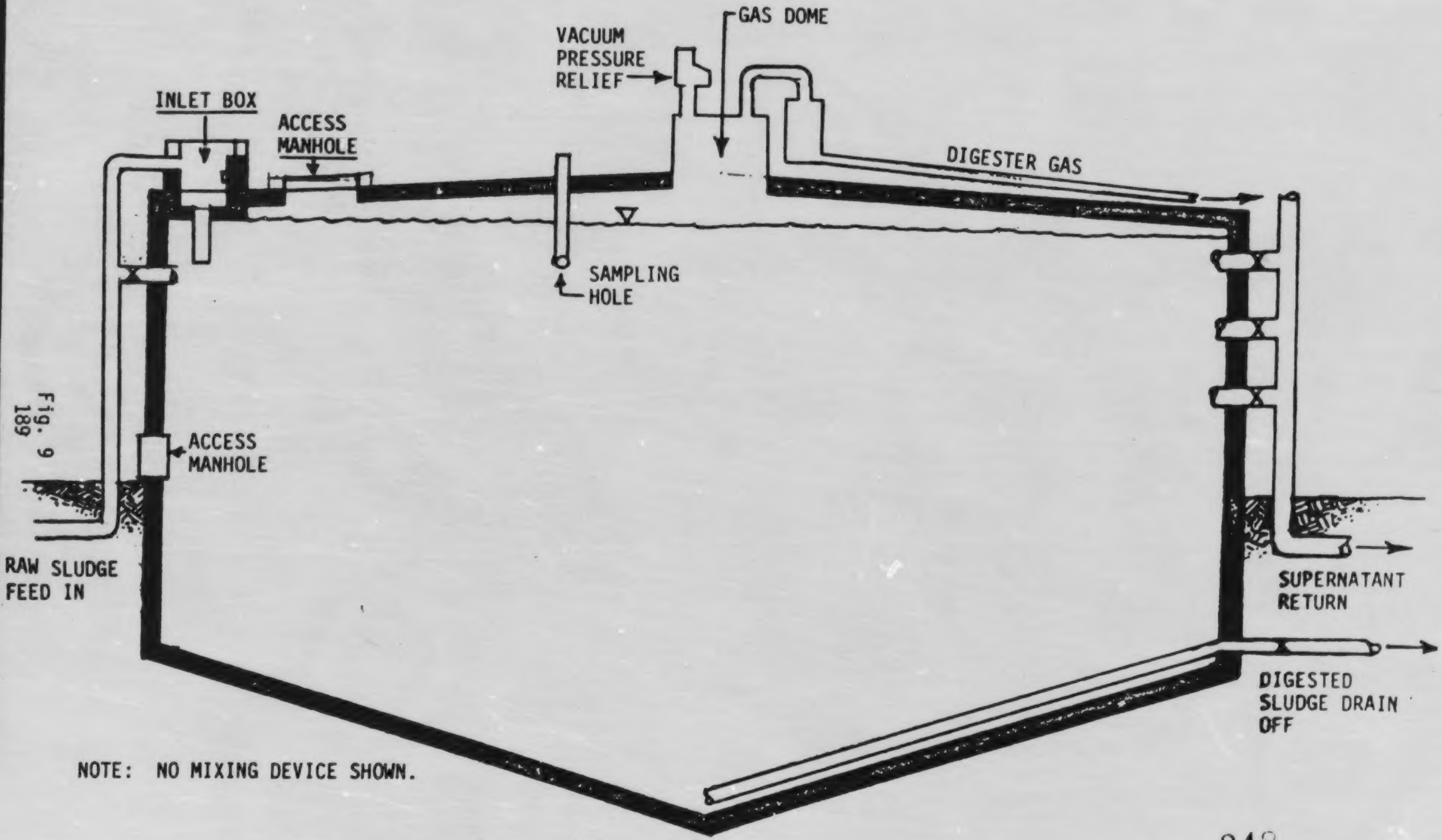

SLUDGE FROM PRIMARY CLARIFIERS
ANAEROBIC SLUDGE DIGESTION
CHEMICAL CONDITIONING
VACUUM FILTRATION
DEWATERED SOLIDS TO LANDFILL OR SPREAD ON SOIL
FIRST STAGE
SECOND STAGE
CHEMICALS
DEWATERED SOLIDS
LIQUID
SUPERNATANT
PLAN
(TOP VIEW)
GAS STORAGE
MIXING
SLUDGE HEATER
GAS STORAGE
SCUM
SUPERNATANT
DIGESTED SLUDGE
SUPERNATANT TO PLANT INFLUENT
CHEMICALS
DEWATERED SOLIDS OFF FILTER TO DISPOSAL
FILTERED LIQUID TO PLANT INFLUENT
PROFILE
(SIDE VIEW)

Fig. 8.b

Possible sludge processing and solids disposal flow pattern (vacuum filtration)

Fig. 9
189


GAS DOME
VACUUM PRESSURE RELIEF
INLET BOX
ACCESS MANHOLE
DIGESTER GAS
SAMPLING HOLE
ACCESS MANHOLE
RAW SLUDGE FEED IN
SUPERNATANT RETURN
DIGESTED SLUDGE DRAIN OFF
NOTE: NO MIXING DEVICE SHOWN.

Section of sludge digester

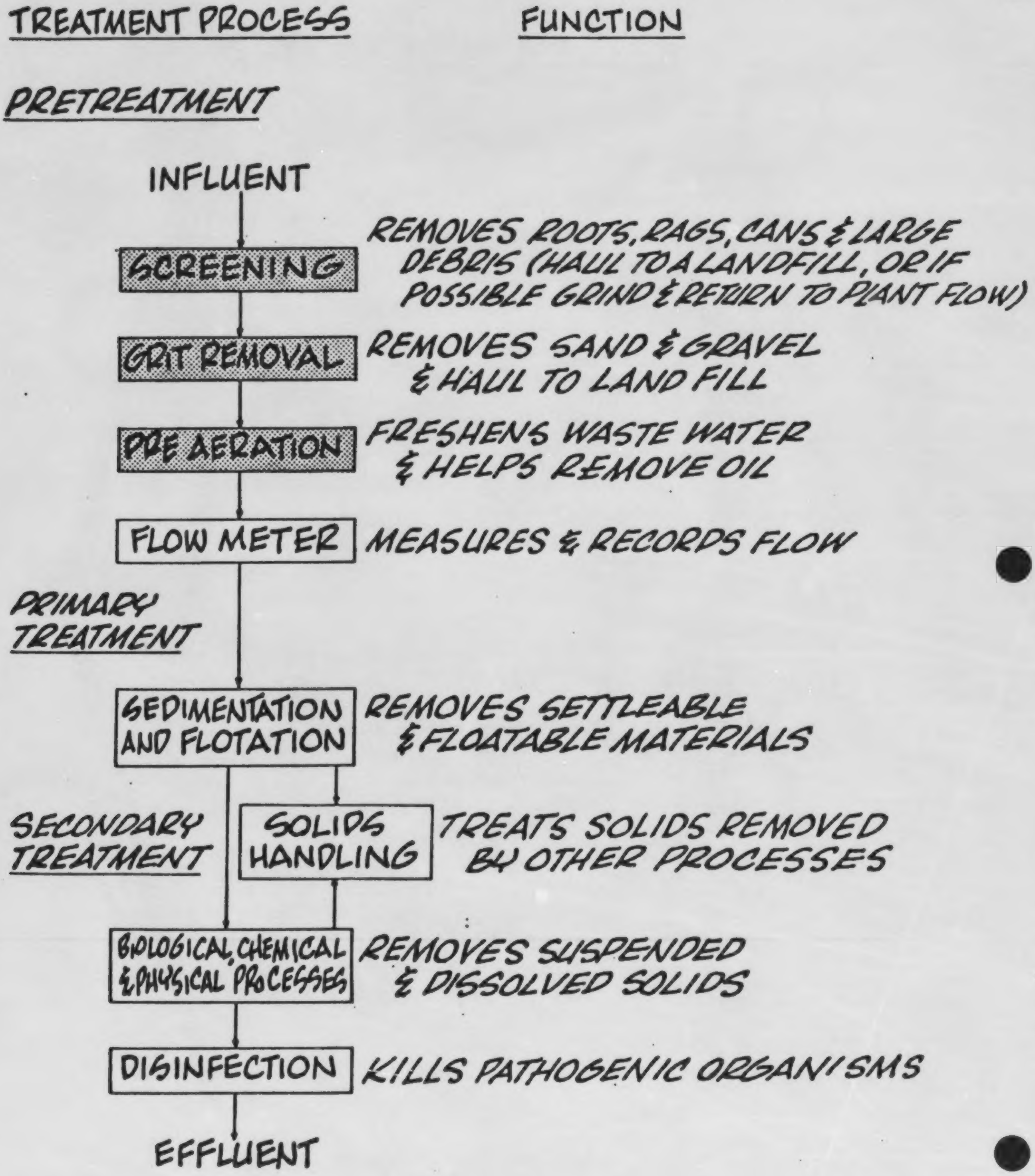

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 10

249

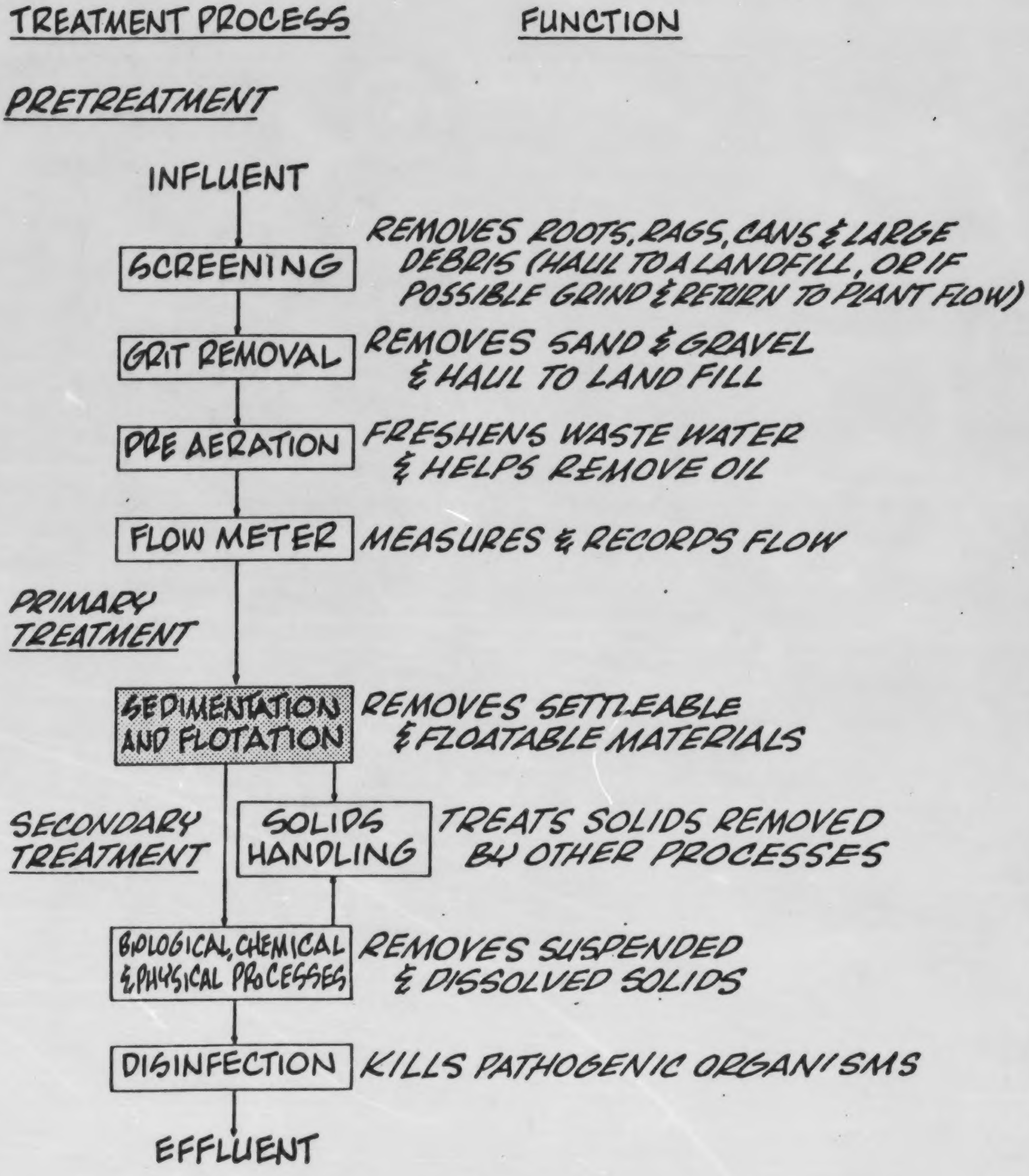
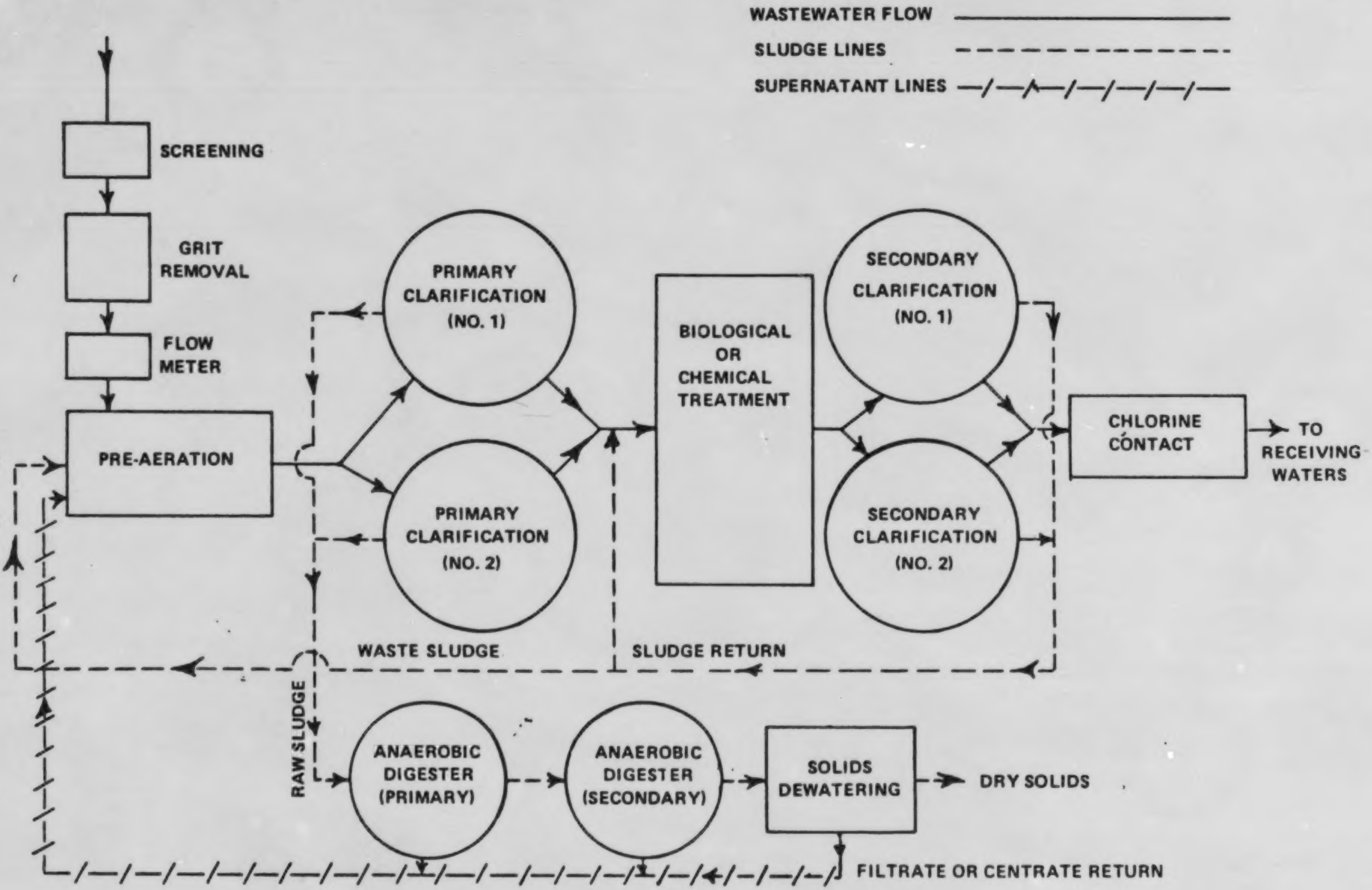

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 11

Fig. 12

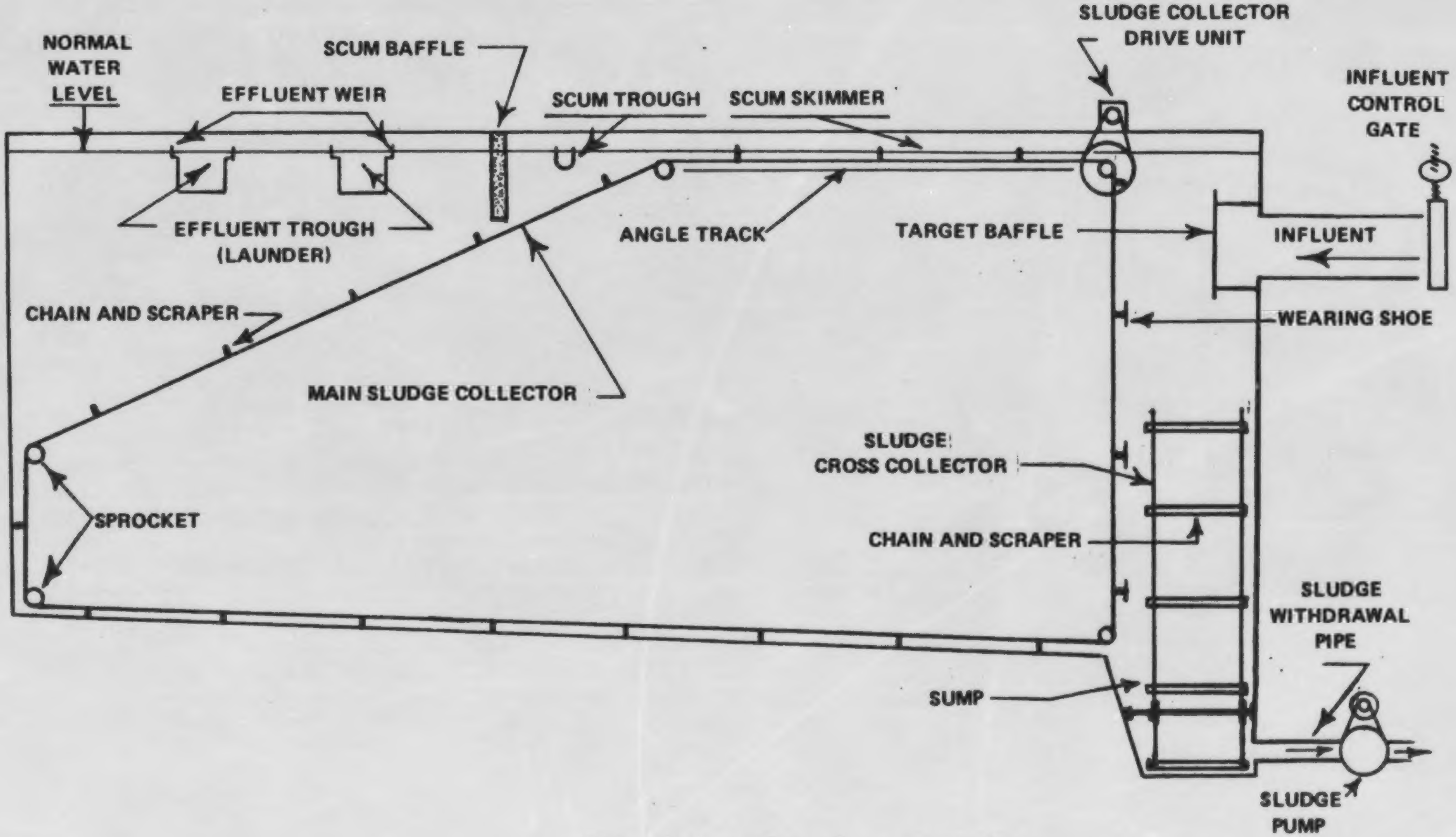
192


WASTEWATER FLOW
SLUDGE LINES
SUPERNATANT LINES
SCREENING
GRIT REMOVAL
FLOW METER
PRE-AERATION
PRIMARY CLARIFICATION (NO. 1)
PRIMARY CLARIFICATION (NO. 2)
BIOLOGICAL OR CHEMICAL TREATMENT
SECONDARY CLARIFICATION (NO. 1)
SECONDARY CLARIFICATION (NO. 2)
CHLORINE CONTACT
TO RECEIVING WATERS
WASTE SLUDGE
SLUDGE RETURN
RAW SLUDGE
ANAEROBIC DIGESTER (PRIMARY)
ANAEROBIC DIGESTER (SECONDARY)
SOLIDS DEWATERING
DRY SOLIDS
FILTRATE OR CENTRATE RETURN

Plan diagram of typical clarifiers in a wastewater treatment plant

Fig. 13

193


NORMAL WATER LEVEL
EFFLUENT WEIR
SCUM BAFFLE
SCUM TROUGH
SCUM SKIMMER
SLUDGE COLLECTOR DRIVE UNIT
INFLUENT CONTROL GATE
EFFLUENT TROUGH (LAUNDER)
ANGLE TRACK
TARGET BAFFLE
INFLUENT
WEARING SHOE
CHAIN AND SCRAPER
MAIN SLUDGE COLLECTOR
SLUDGE CROSS COLLECTOR
SPROCKET
CHAIN AND SCRAPER
SLUDGE WITHDRAWAL PIPE
SUMP
SLUDGE PUMP

Side-view section of a rectangular sedimentation basin

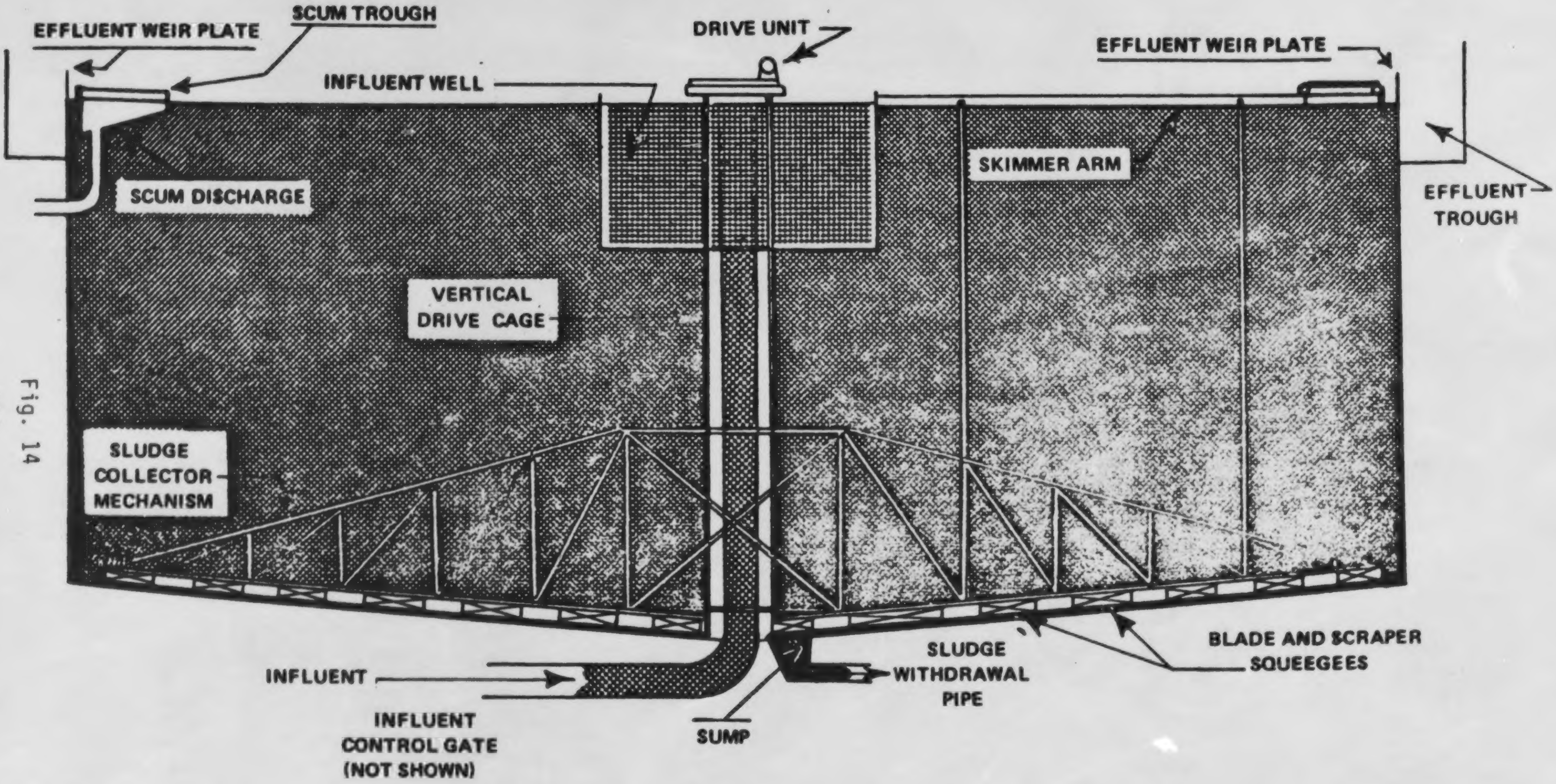

EFFLUENT WEIR PLATE
SCUM TROUGH
DRIVE UNIT
EFFLUENT WEIR PLATE
INFLUENT WELL
SKIMMER ARM
SCUM DISCHARGE
EFFLUENT TROUGH
VERTICAL DRIVE CAGE
SLUDGE COLLECTOR MECHANISM
BLADE AND SCRAPER SQUEEGEES
SLUDGE WITHDRAWAL PIPE
INFLUENT
INFLUENT CONTROL GATE (NOT SHOWN)
SUMP

Fig. 14

Side-view section of a circular clarifier with blades and scraper squeegees

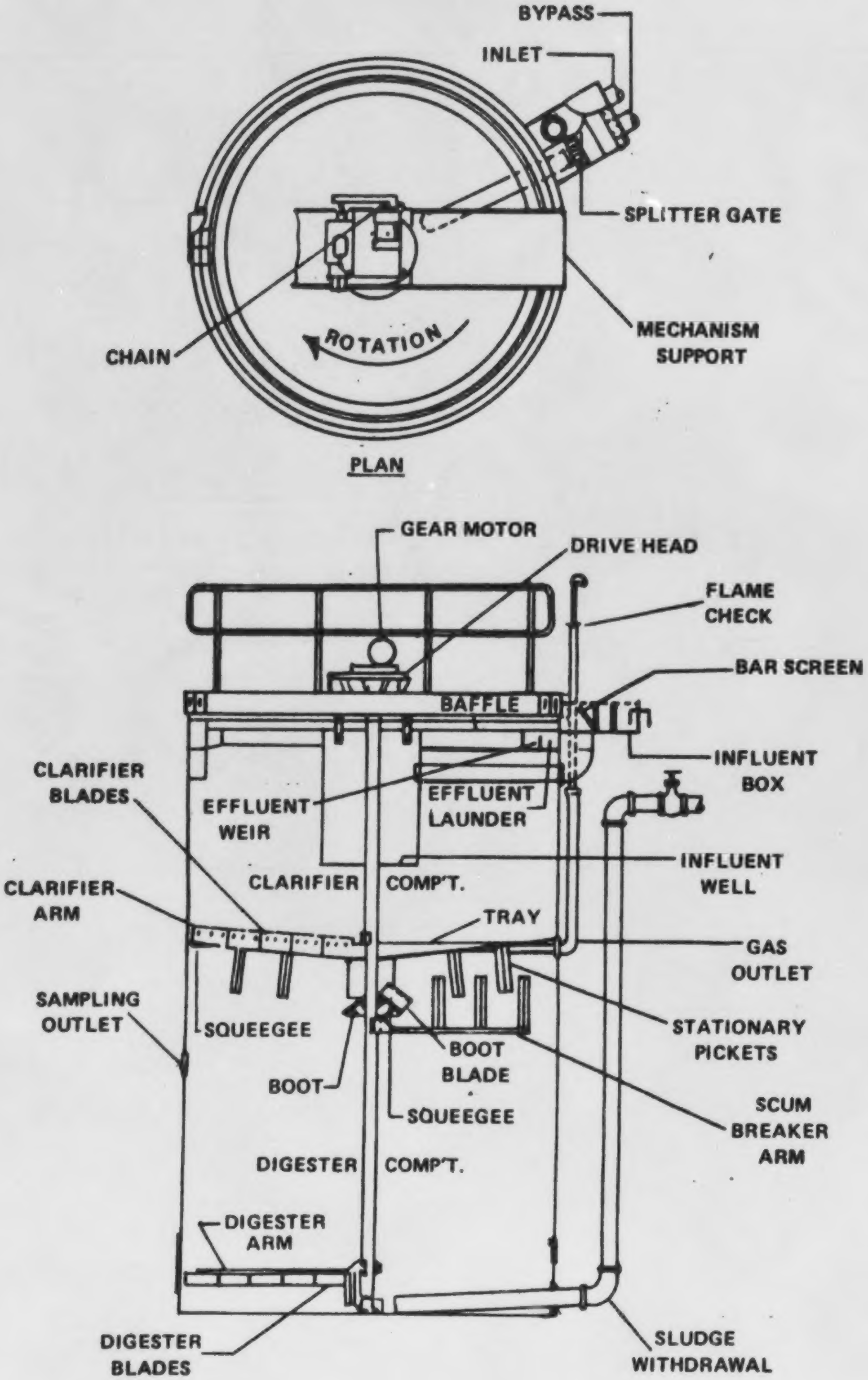

BYPASS
INLET
SPLITTER GATE
MECHANISM SUPPORT
CHAIN
ROTATION
PLAN
GEAR MOTOR
DRIVE HEAD
FLAME CHECK
BAR SCREEN
BAFFLE
INFLUENT BOX
CLARIFIER BLADES
EFFLUENT WEIR
EFFLUENT LAUNDER
INFLUENT WELL
CLARIFIER ARM
CLARIFIER COMP'T.
TRAY
GAS OUTLET
STATIONARY PICKETS
SAMPLING OUTLET
SQUEEGEE
BOOT BLADE
BOOT
SQUEEGEE
SCUM BREAKER ARM
DIGESTER COMP'T.
DIGESTER ARM
DIGESTER BLADES
SLUDGE WITHDRAWAL

Fig. 15 Combined sedimentation-digestion unit
(Permission of Dorr-Oliver Incorporated)

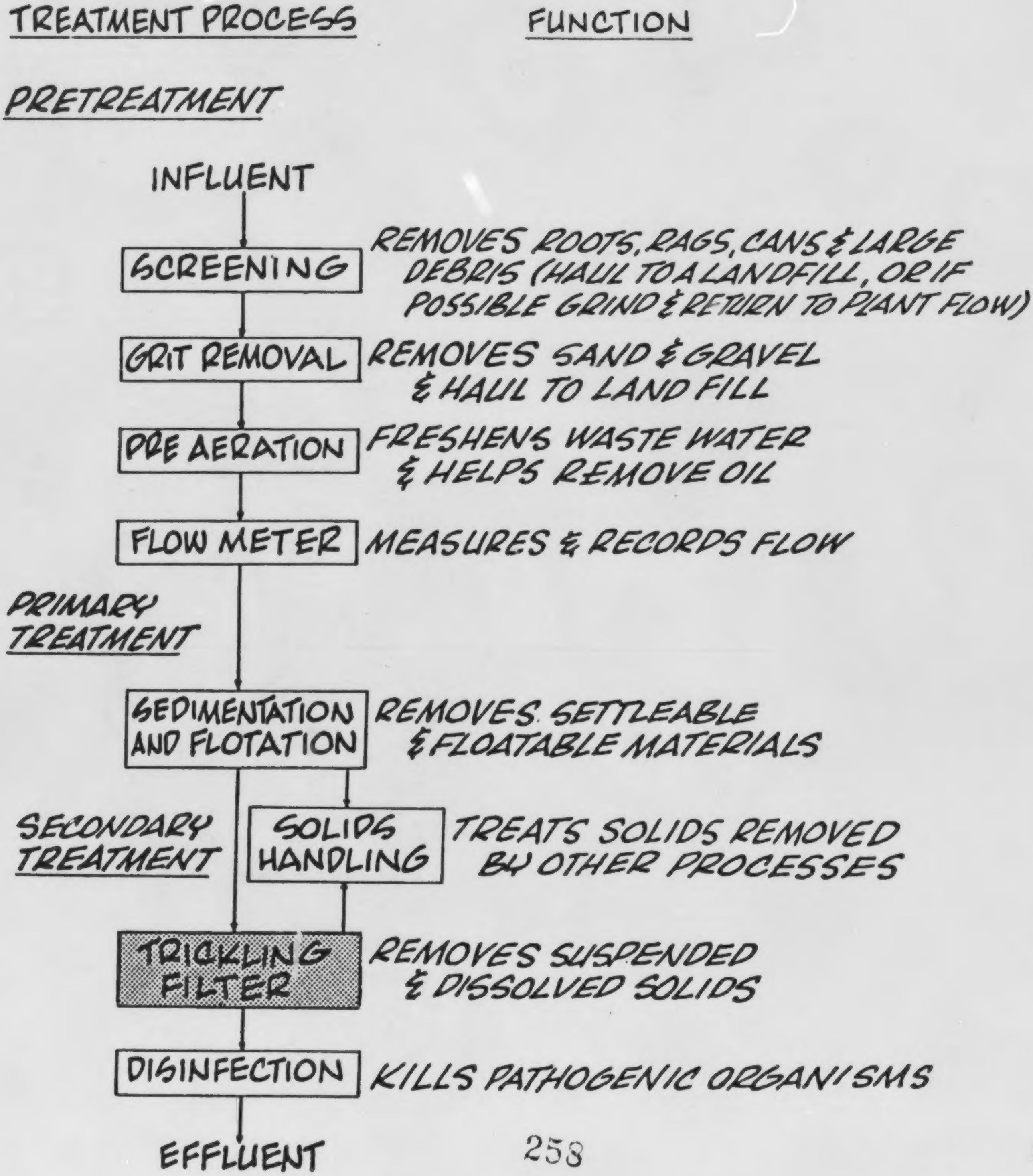
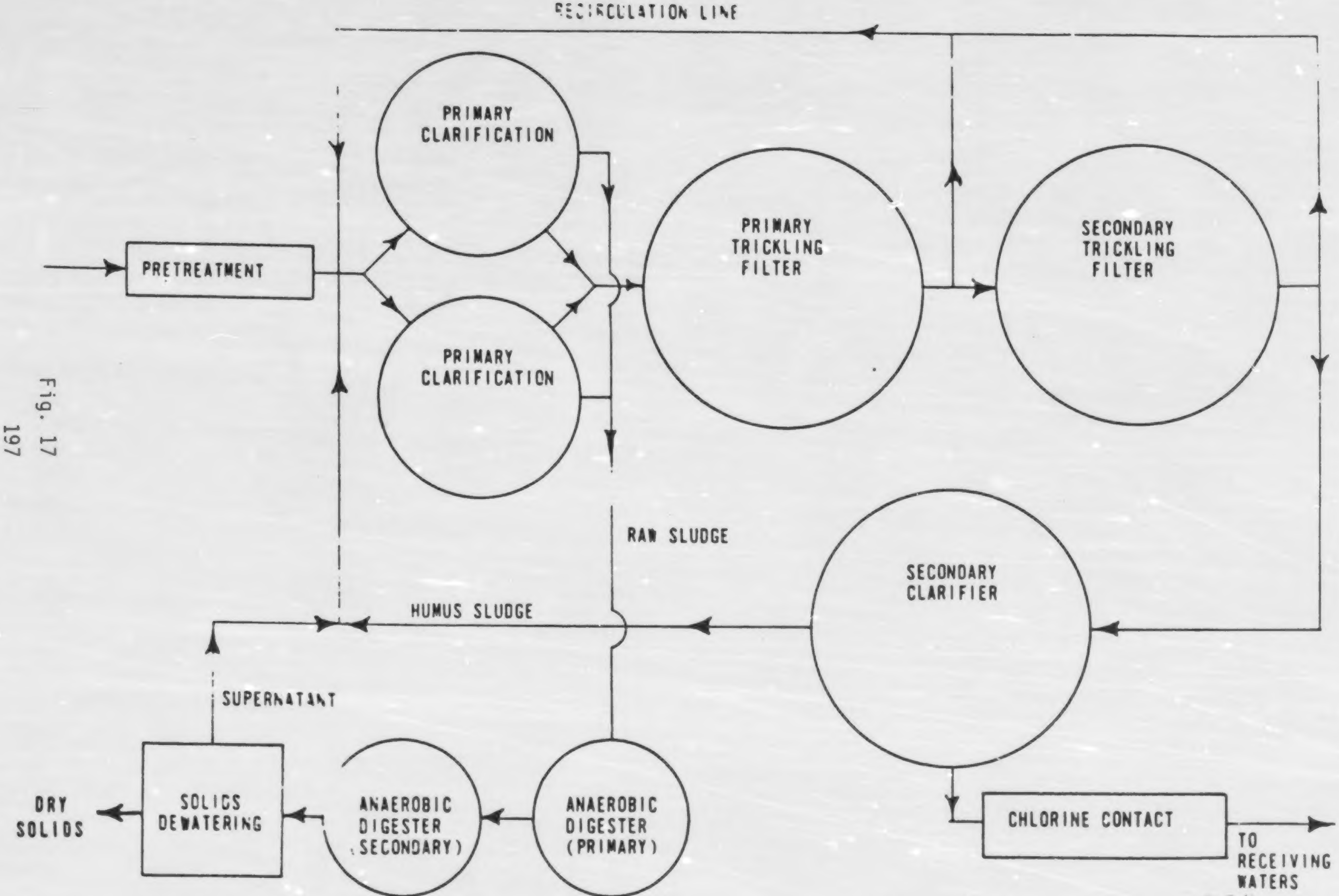

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
TRICKLING FILTER
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 16

Fig. 17


RECIRCULATION LINE
PRIMARY CLARIFICATION
PRIMARY CLARIFICATION
PRETREATMENT
PRIMARY TRICKLING FILTER
SECONDARY TRICKLING FILTER
RAW SLUDGE
SECONDARY CLARIFIER
HUMUS SLUDGE
SUPERNATANT
DRY SOLIDS
SOLIDS DEWATERING
ANAEROBIC DIGESTER (SECONDARY)
ANAEROBIC DIGESTER (PRIMARY)
CHLORINE CONTACT
TO RECEIVING WATERS

Plan of typical trickling filter plant

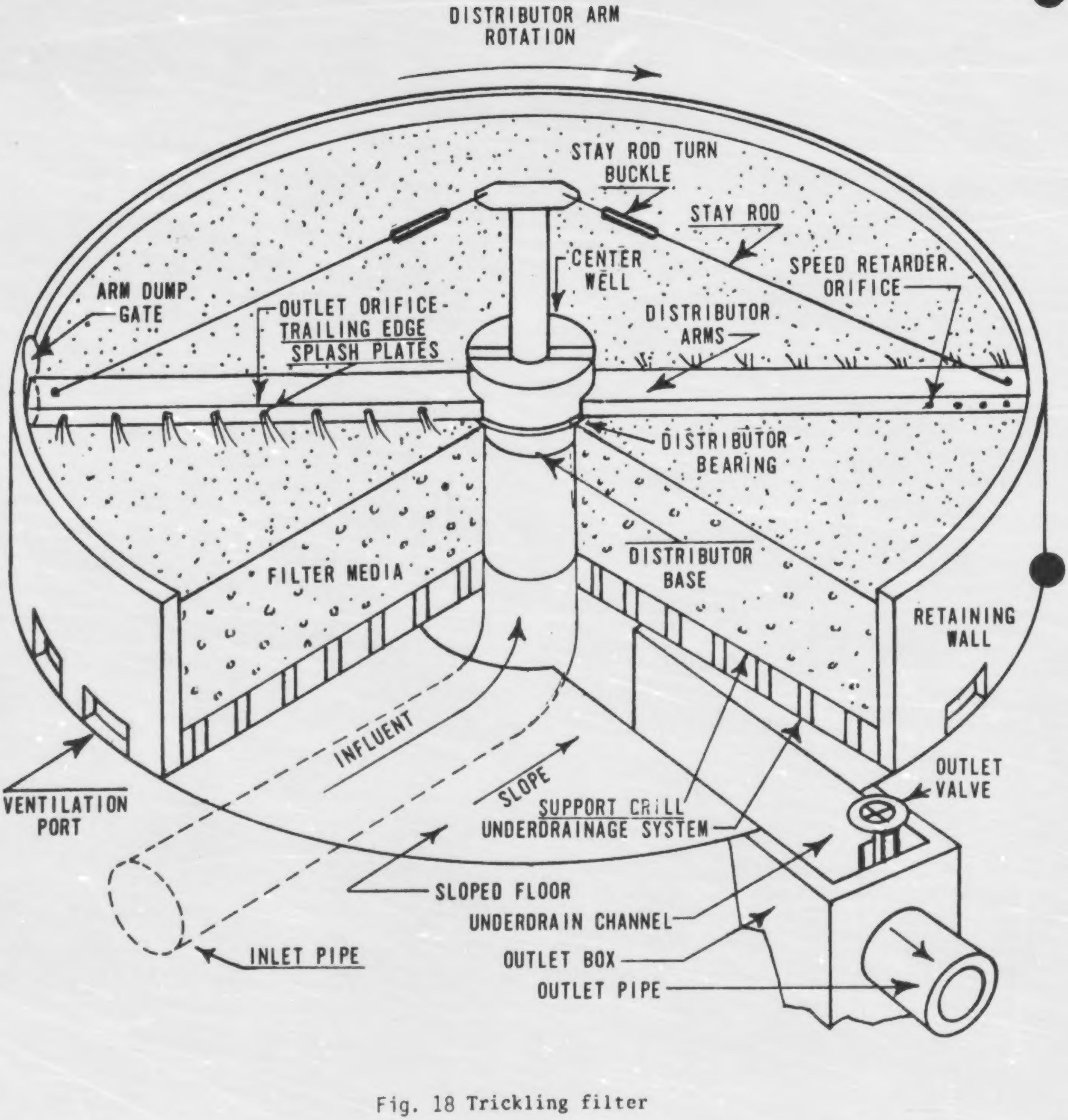
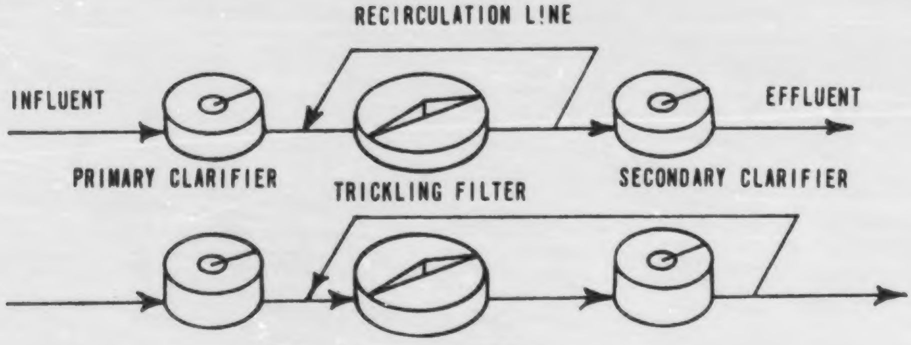
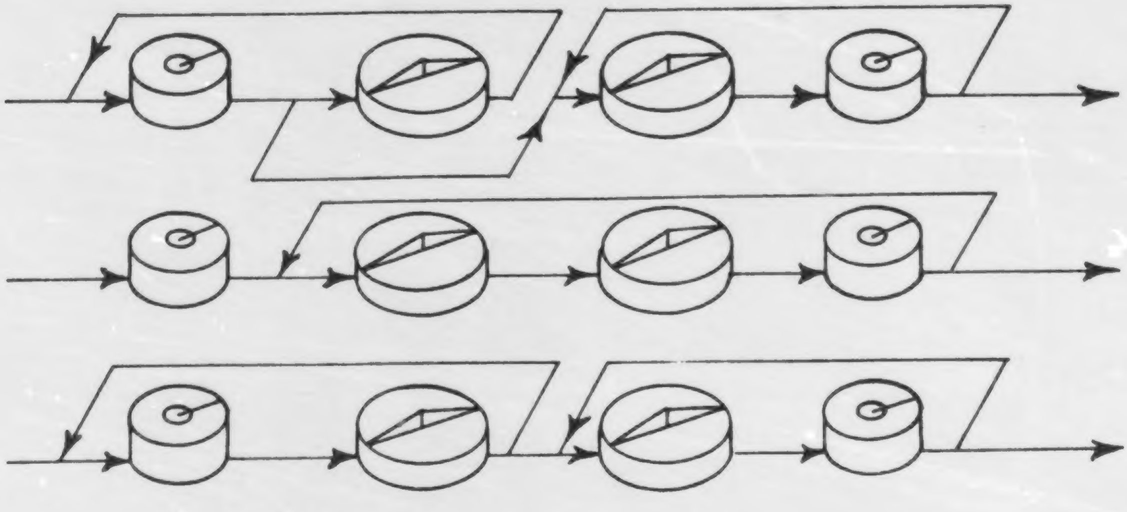

DISTRIBUTOR ARM ROTATION
STAY ROD TURN BUCKLE
STAY ROD
CENTER WELL
SPEED RETARDER ORIFICE
ARM DUMP GATE
OUTLET ORIFICE
TRAILING EDGE
SPLASH PLATES
DISTRIBUTOR ARMS
DISTRIBUTOR BEARING
DISTRIBUTOR BASE
FILTER MEDIA
RETAINING WALL
INFLUENT
SLOPE
OUTLET VALVE
VENTILATION PORT
SUPPORT GRILL
UNDERDRAINAGE SYSTEM
SLOPED FLOOR
UNDERDRAIN CHANNEL
OUTLET BOX
OUTLET PIPE
INLET PIPE

Fig. 18 Trickling filter


RECIRCULATION LINE
INFLUENT
EFFLUENT
PRIMARY CLARIFIER
TRICKLING FILTER
SECONDARY CLARIFIER

Typical Single-Stage Recirculation Patterns



Typical Two-Stage Recirculation Patterns

Fig. 19 Trickling filter recirculation patterns

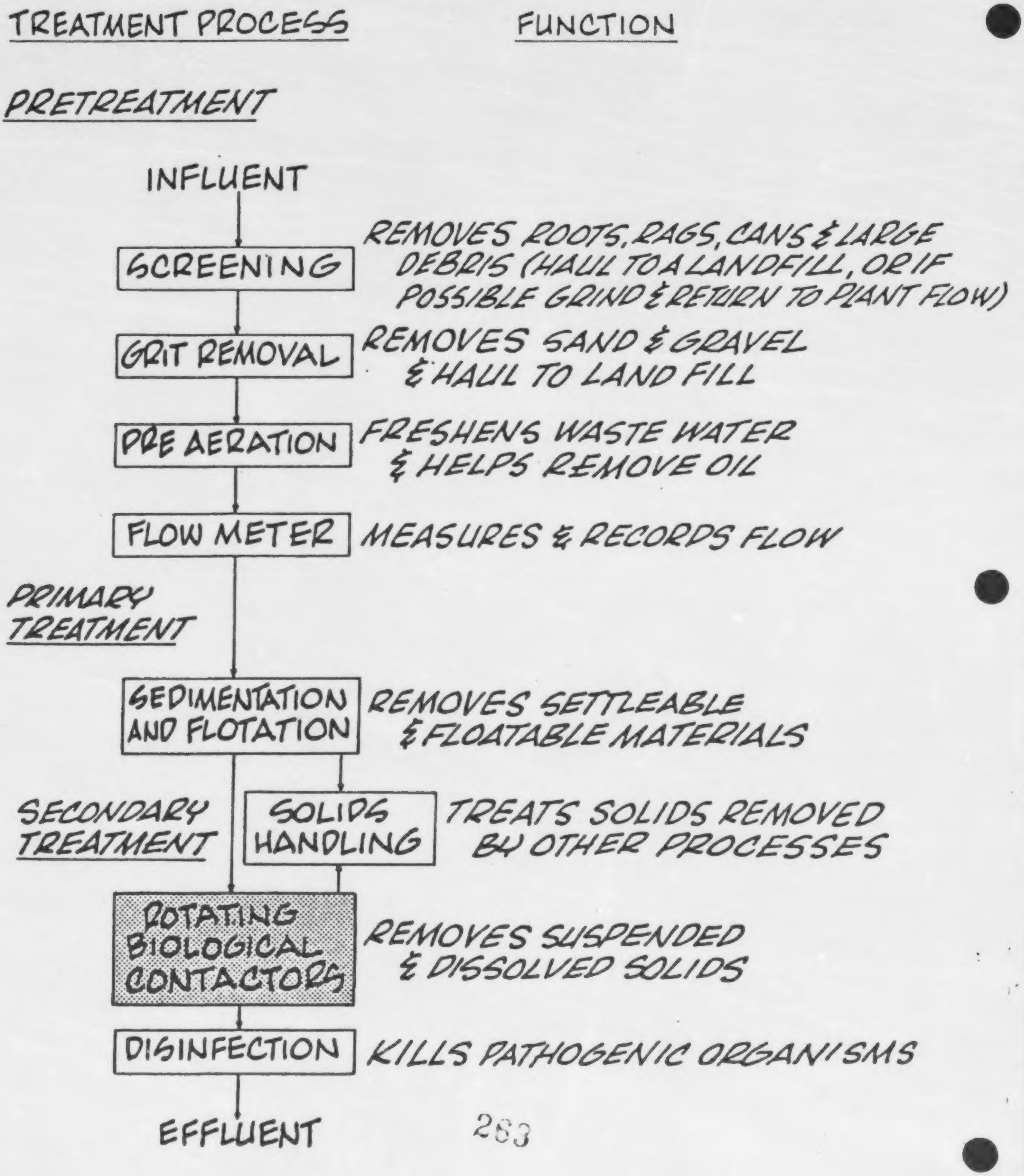

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
ROTATING BIOLOGICAL CONTACTORS
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

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Fig. 20

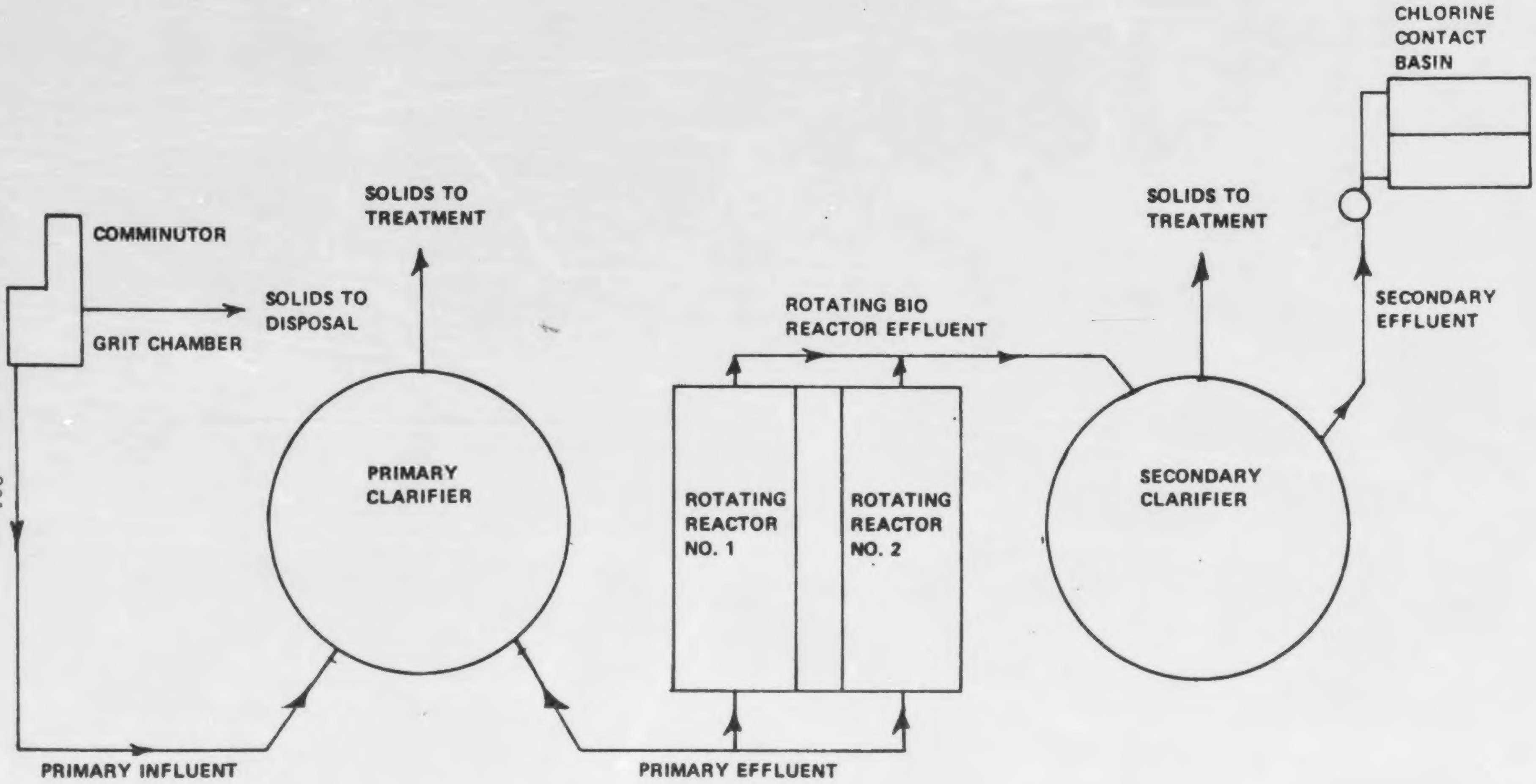
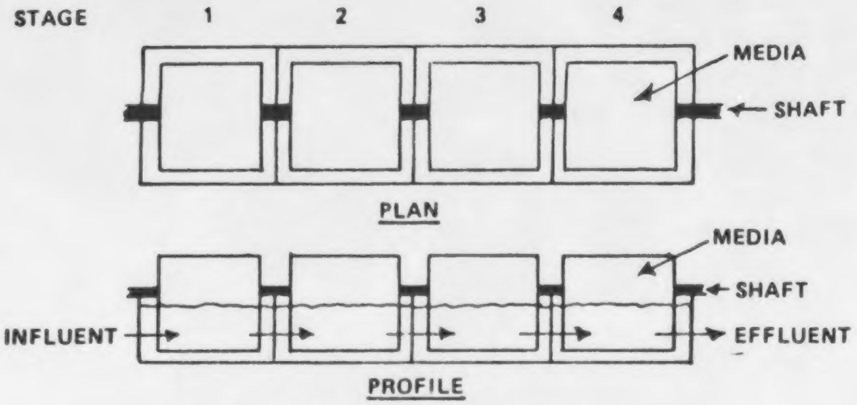
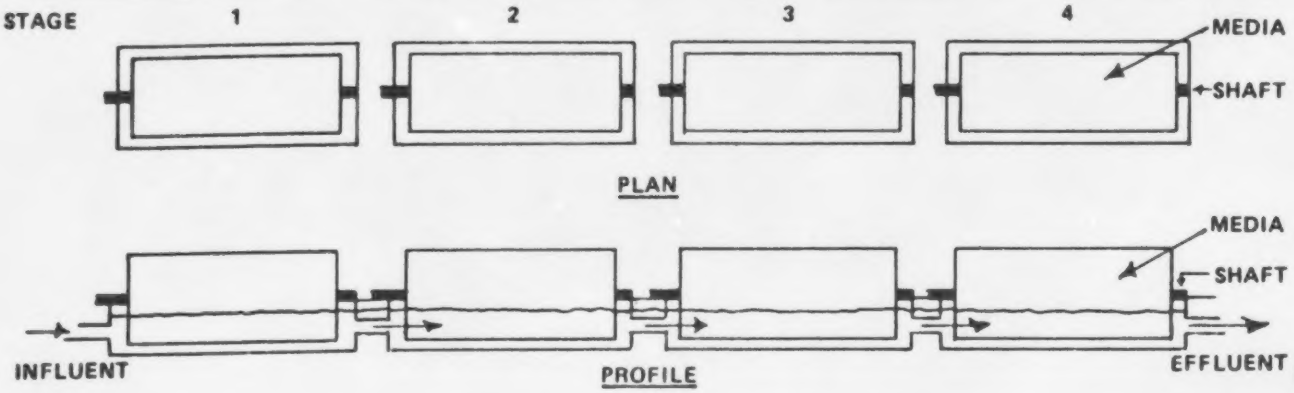

CHLORINE CONTACT BASIN
SOLIDS TO TREATMENT
SOLIDS TO TREATMENT
COMMINUTOR
SOLIDS TO DISPOSAL
GRIT CHAMBER
ROTATING BIO REACTOR EFFLUENT
SECONDARY EFFLUENT
PRIMARY CLARIFIER
ROTATING REACTOR NO. 1
ROTATING REACTOR NO. 2
SECONDARY CLARIFIER
PRIMARY INFLUENT
PRIMARY EFFLUENT

Fig. 21

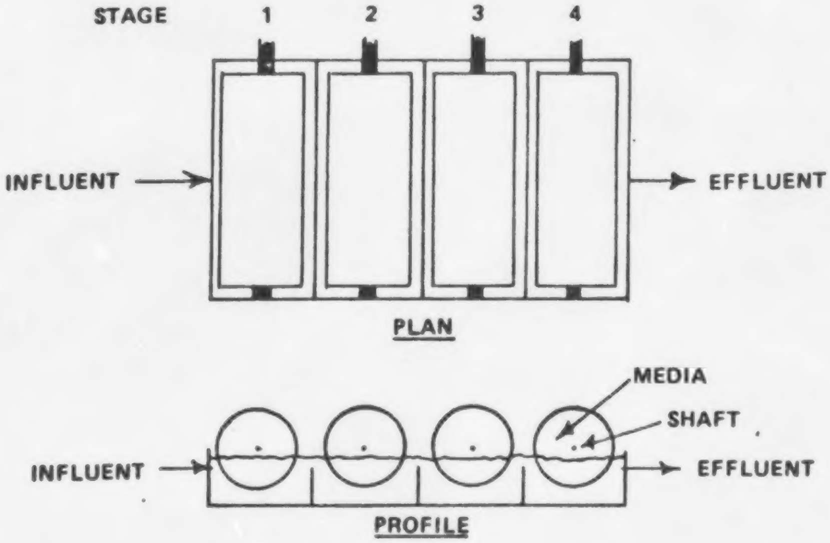
Typical rotating biological contactor treatment plant


STAGE
1
2
3
4
MEDIA
SHAFT
PLAN
MEDIA
SHAFT
INFLUENT
EFFLUENT
PROFILE

LAYOUT NO. 1 ONE SHAFT, FOUR STAGES
FLOW PARALLEL TO SHAFT


STAGE
1
2
3
4
MEDIA
SHAFT
PLAN
MEDIA
SHAFT
INFLUENT
EFFLUENT
PROFILE

LAYOUT NO. 2 FOUR SHAFTS, FOUR STAGES
FLOW PARALLEL TO SHAFT


STAGE
1
2
3
4
INFLUENT
EFFLUENT
PLAN
MEDIA
SHAFT
INFLUENT
EFFLUENT
PROFILE

LAYOUT NO. 3 FOUR SHAFTS, FOUR STAGES
FLOW PERPENDICULAR TO SHAFT

Fig. 22 Possible rotating biological contactor layouts

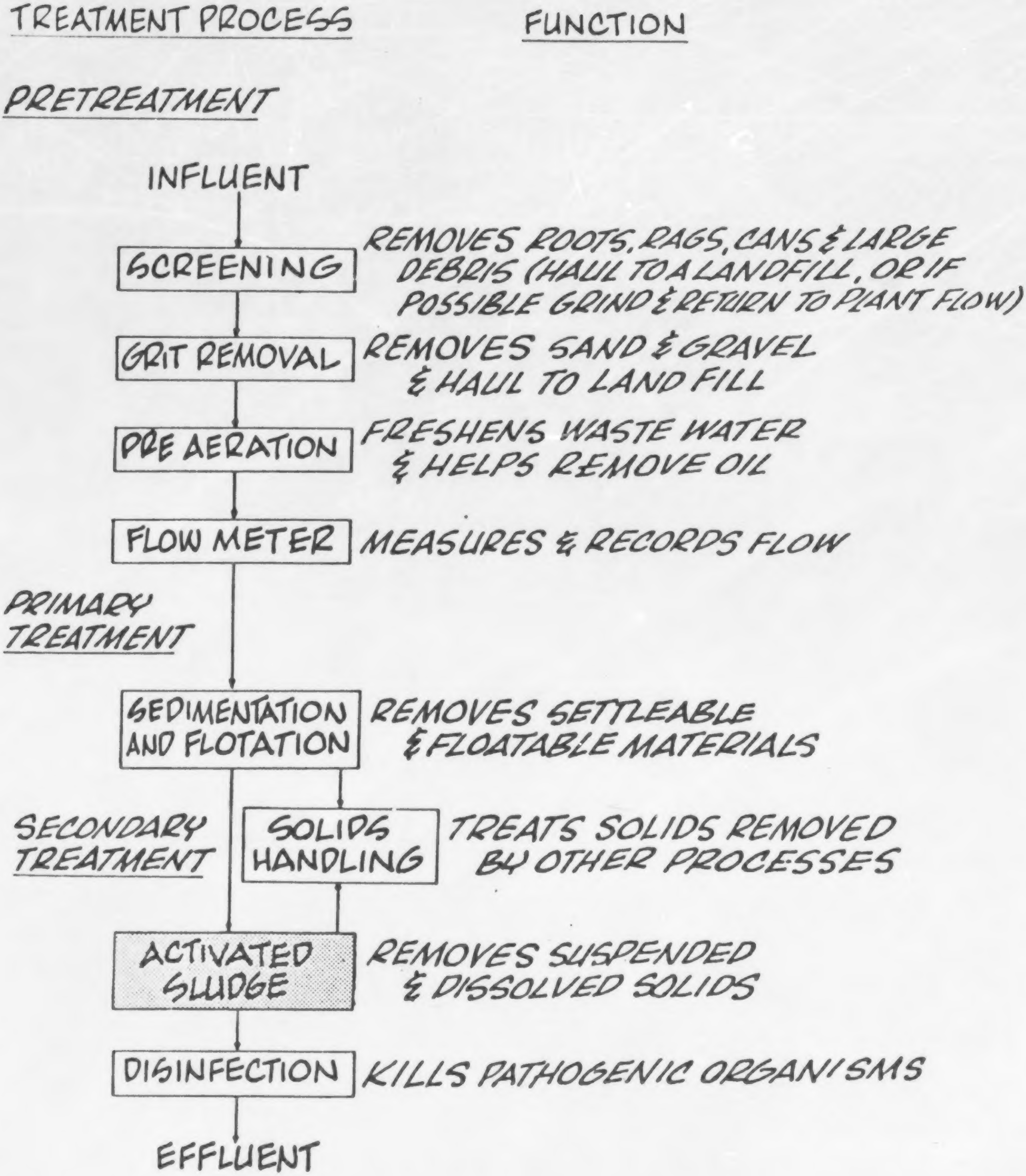

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
ACTIVATED SLUDGE
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 23

Fig. 24
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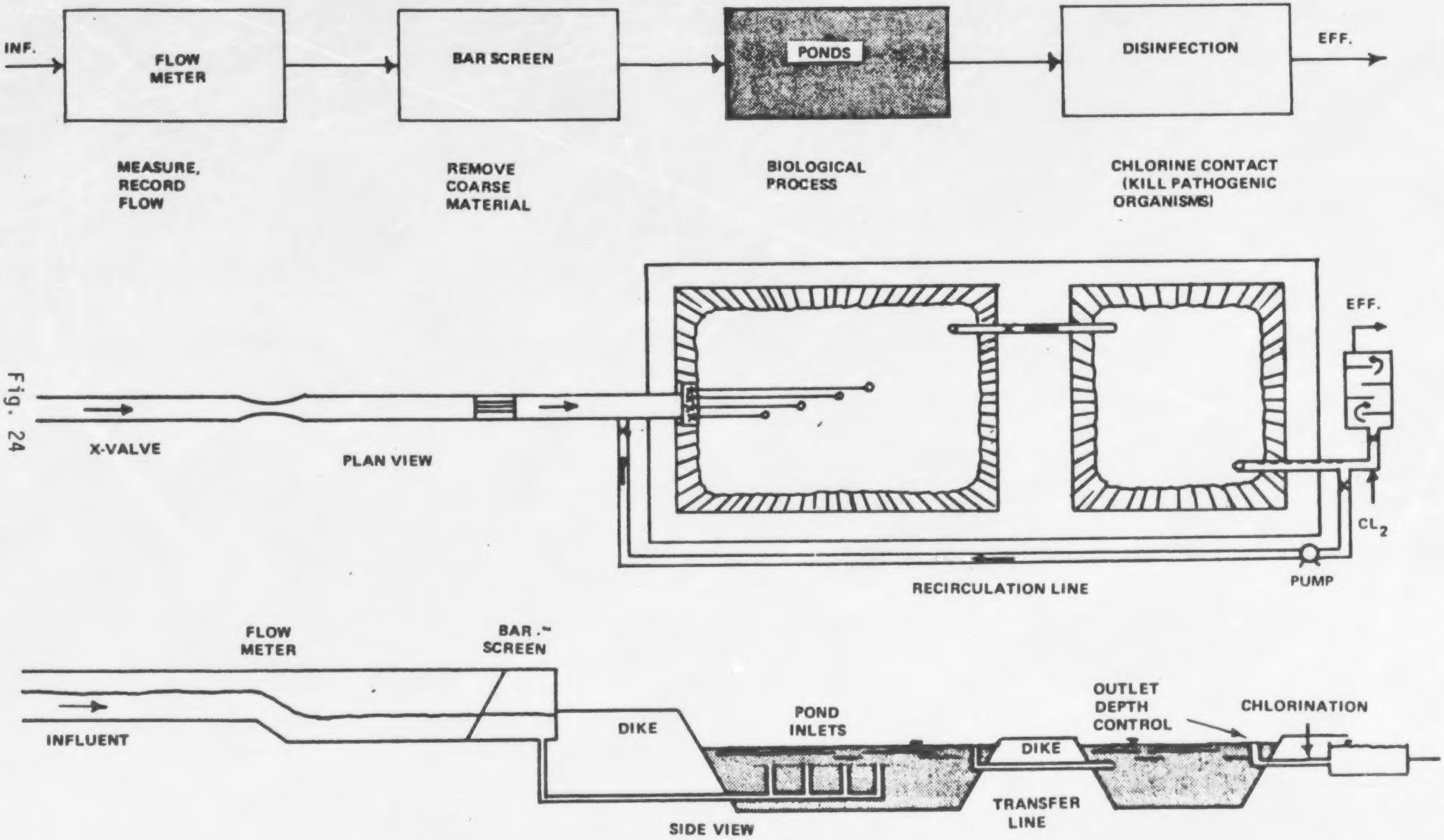
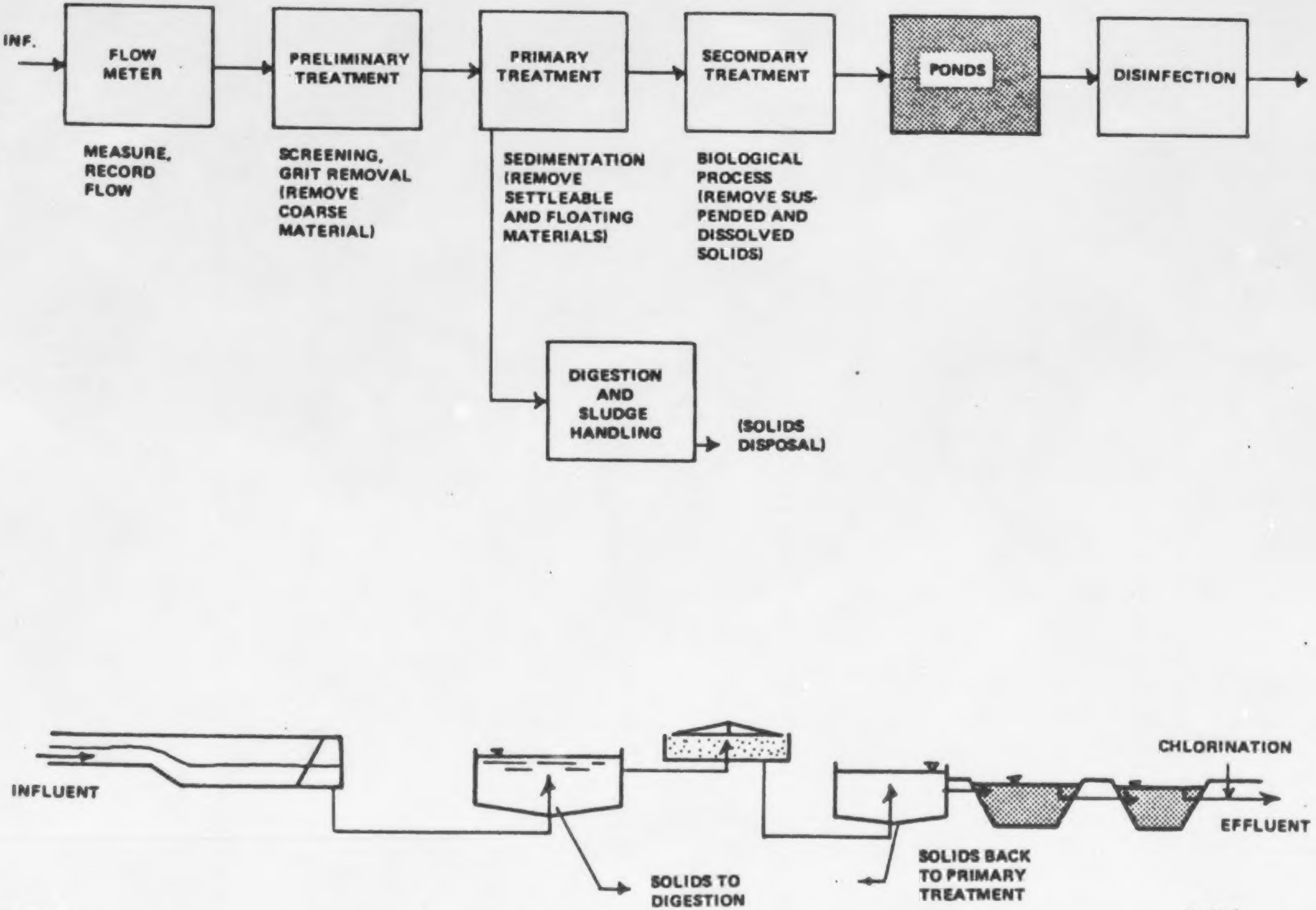
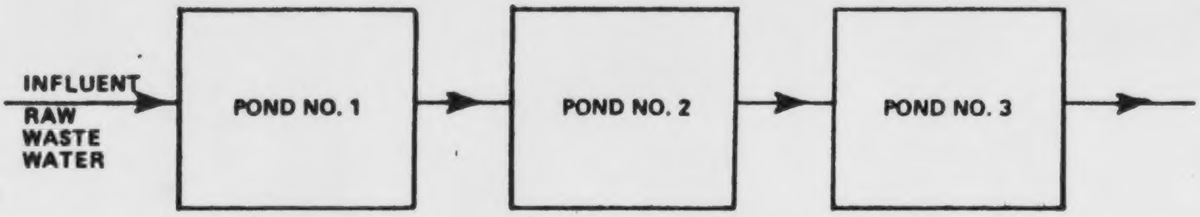

INF.
FLOW METER
BAR SCREEN
PONDS
DISINFECTION
EFF.
MEASURE, RECORD FLOW
REMOVE COARSE MATERIAL
BIOLOGICAL PROCESS
CHLORINE CONTACT (KILL PATHOGENIC ORGANISMS)
X-VALVE
PLAN VIEW
EFF.
CL2
RECIRCULATION LINE
PUMP
FLOW METER
BAR SCREEN
INFLUENT
DIKE
POND INLETS
DIKE
OUTLET DEPTH CONTROL
CHLORINATION
TRANSFER LINE
SIDE VIEW

Typical plant; ponds only

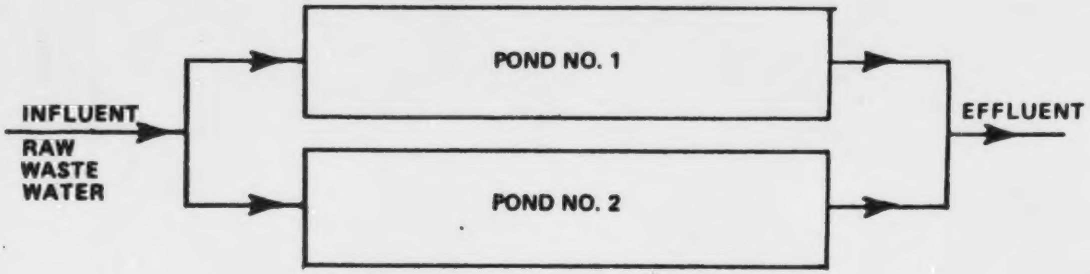
Fig. 25


INF.
FLOW METER
PRELIMINARY TREATMENT
PRIMARY TREATMENT
SECONDARY TREATMENT
PONDS
DISINFECTION
MEASURE, RECORD FLOW
SCREENING, GRIT REMOVAL (REMOVE COARSE MATERIAL)
SEDIMENTATION (REMOVE SETTLEABLE AND FLOATING MATERIALS)
BIOLOGICAL PROCESS (REMOVE SUSPENDED AND DISSOLVED SOLIDS)
DIGESTION AND SLUDGE HANDLING
(SOLIDS DISPOSAL)
INFLUENT
CHLORINATION
EFFLUENT
SOLIDS TO DIGESTION
SOLIDS BACK TO PRIMARY TREATMENT

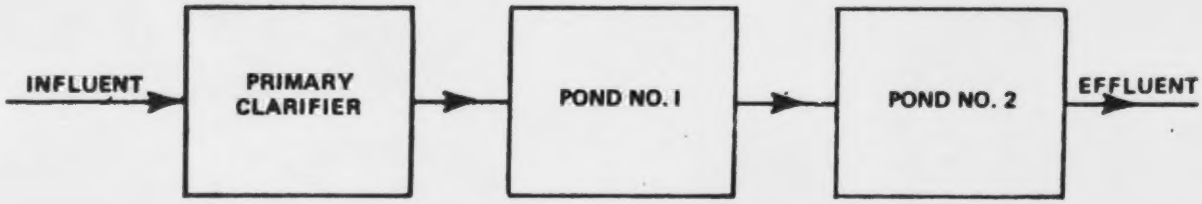
Typical plant; ponds after secondary treatment


INFLUENT
RAW
WASTE
WATER
POND NO. 1
POND NO. 2
POND NO. 3

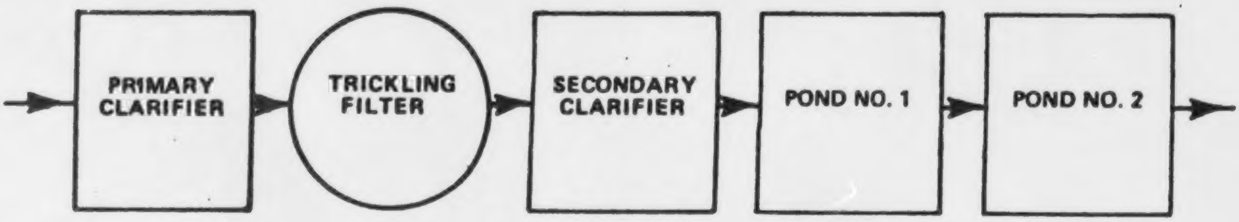
STABILIZATION PONDS IN SERIES


INFLUENT
RAW
WASTE
WATER
POND NO. 1
POND NO. 2
EFFLUENT

STABILIZATION PONDS IN PARALLEL


INFLUENT
PRIMARY
CLARIFIER
POND NO. I
POND NO. 2
EFFLUENT

OXIDATION PONDS IN SERIES


PRIMARY
CLARIFIER
TRICKLING
FILTER
SECONDARY
CLARIFIER
POND NO. 1
POND NO. 2

POLISHING PONDS IN SERIES

Fig. 26 Pond Classifications

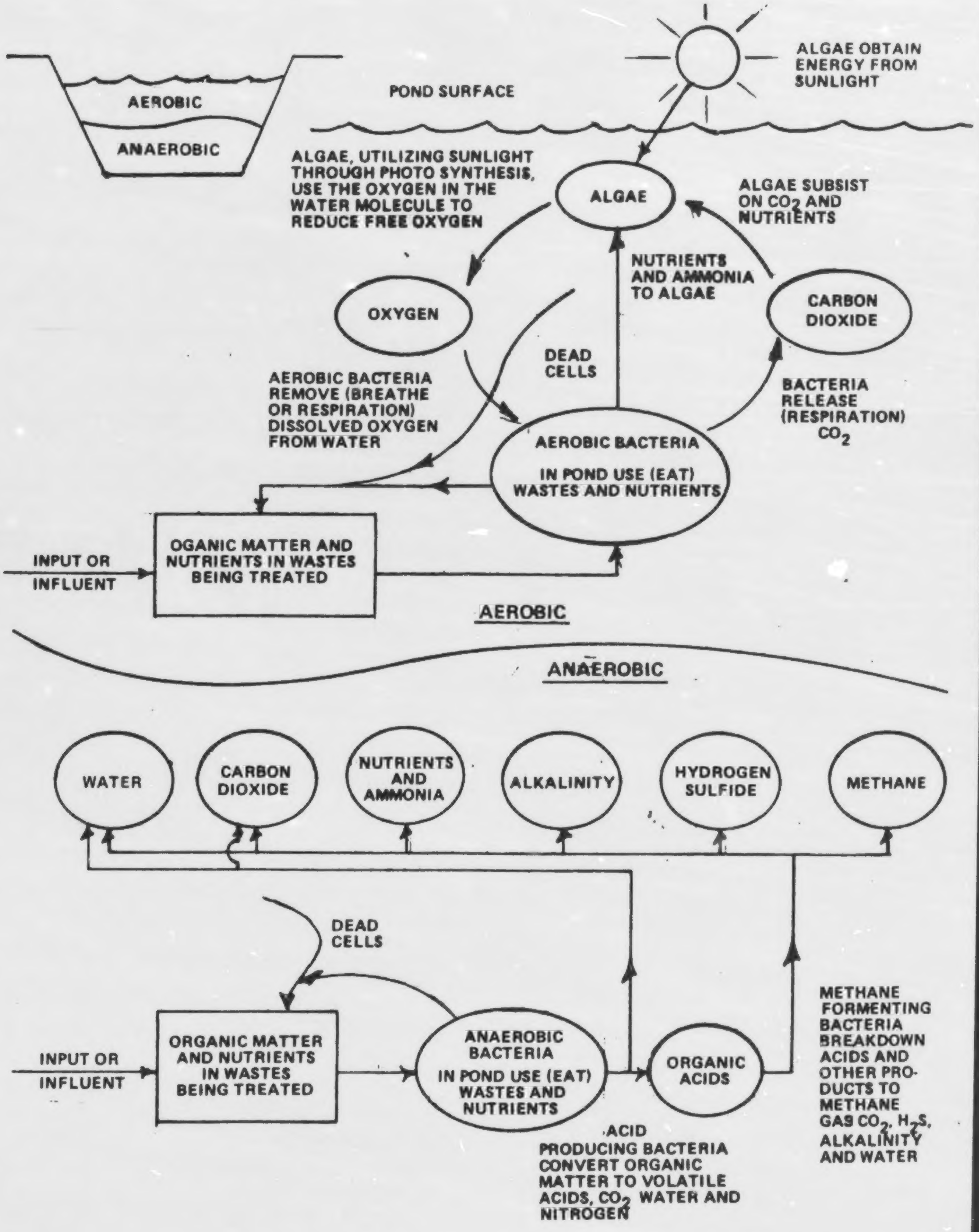

AEROBIC
ANAEROBIC
POND SURFACE
ALGAE OBTAIN ENERGY FROM SUNLIGHT
ALGAE, UTILIZING SUNLIGHT THROUGH PHOTO SYNTHESIS, USE THE OXYGEN IN THE WATER MOLECULE TO REDUCE FREE OXYGEN
ALGAE
ALGAE SUBSIST ON CO2 AND NUTRIENTS
NUTRIENTS AND AMMONIA TO ALGAE
OXYGEN
CARBON DIOXIDE
DEAD CELLS
AEROBIC BACTERIA REMOVE (BREATHE OR RESPIRATION) DISSOLVED OXYGEN FROM WATER
BACTERIA RELEASE (RESPIRATION) CO2
AEROBIC BACTERIA
IN POND USE (EAT) WASTES AND NUTRIENTS
INPUT OR INFLUENT
OGANIC MATTER AND NUTRIENTS IN WASTES BEING TREATED
AEROBIC
ANAEROBIC
WATER
CARBON DIOXIDE
NUTRIENTS AND AMMONIA
ALKALINITY
HYDROGEN SULFIDE
METHANE
DEAD CELLS
INPUT OR INFLUENT
ORGANIC MATTER AND NUTRIENTS IN WASTES BEING TREATED
ANAEROBIC BACTERIA
IN POND USE (EAT) WASTES AND NUTRIENTS
ORGANIC ACIDS
METHANE FORMENTING BACTERIA BREAKDOWN ACIDS AND OTHER PRODUCTS TO METHANE GAS CO2, H2S, ALKALINITY AND WATER
ACID PRODUCING BACTERIA CONVERT ORGANIC MATTER TO VOLATILE ACIDS, CO2 WATER AND NITROGEN

Fig. 27 Process of decomposition in aerobic and anaerobic layers of a pond

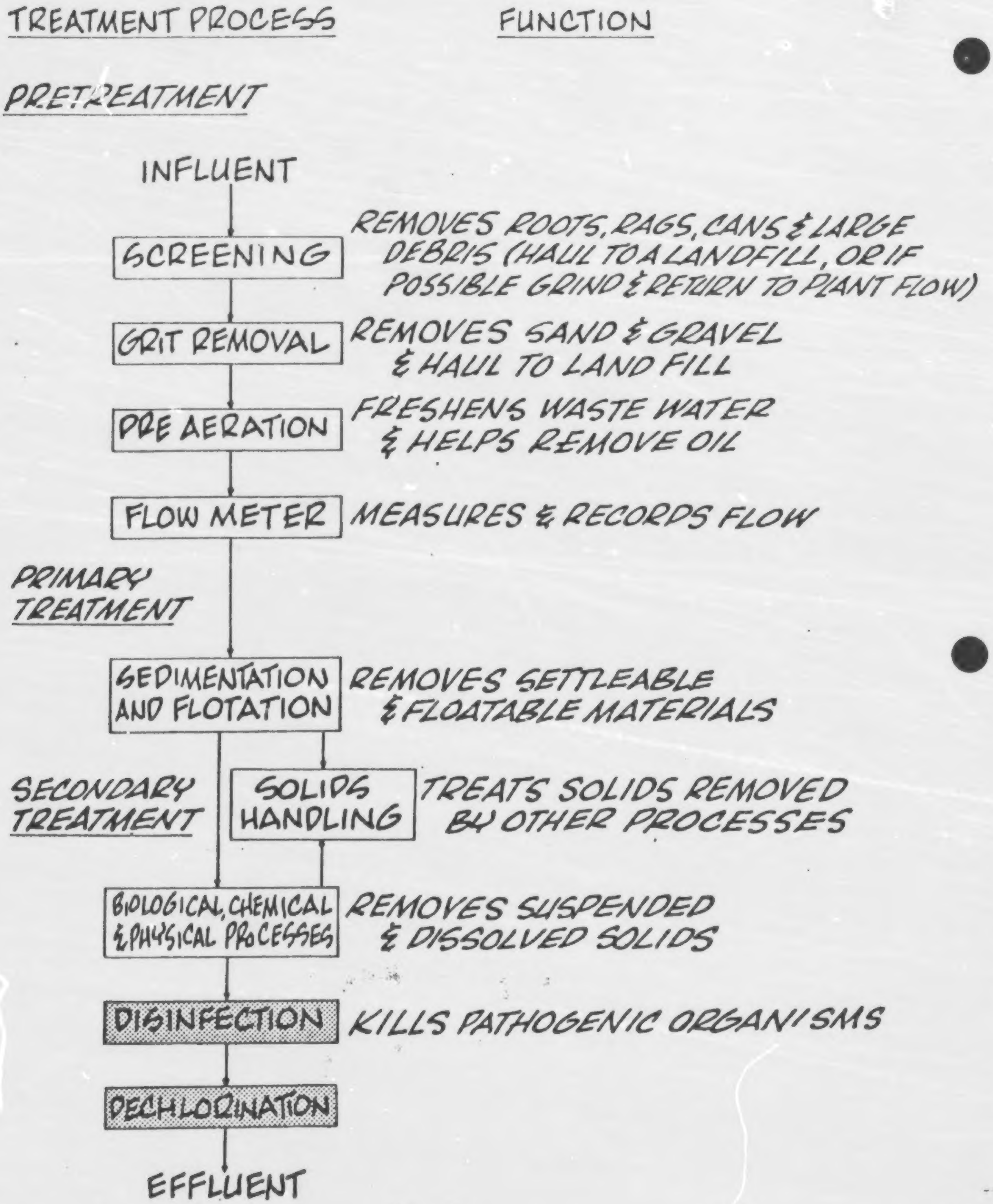

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
DECHLORINATION
EFFLUENT

Fig. 28

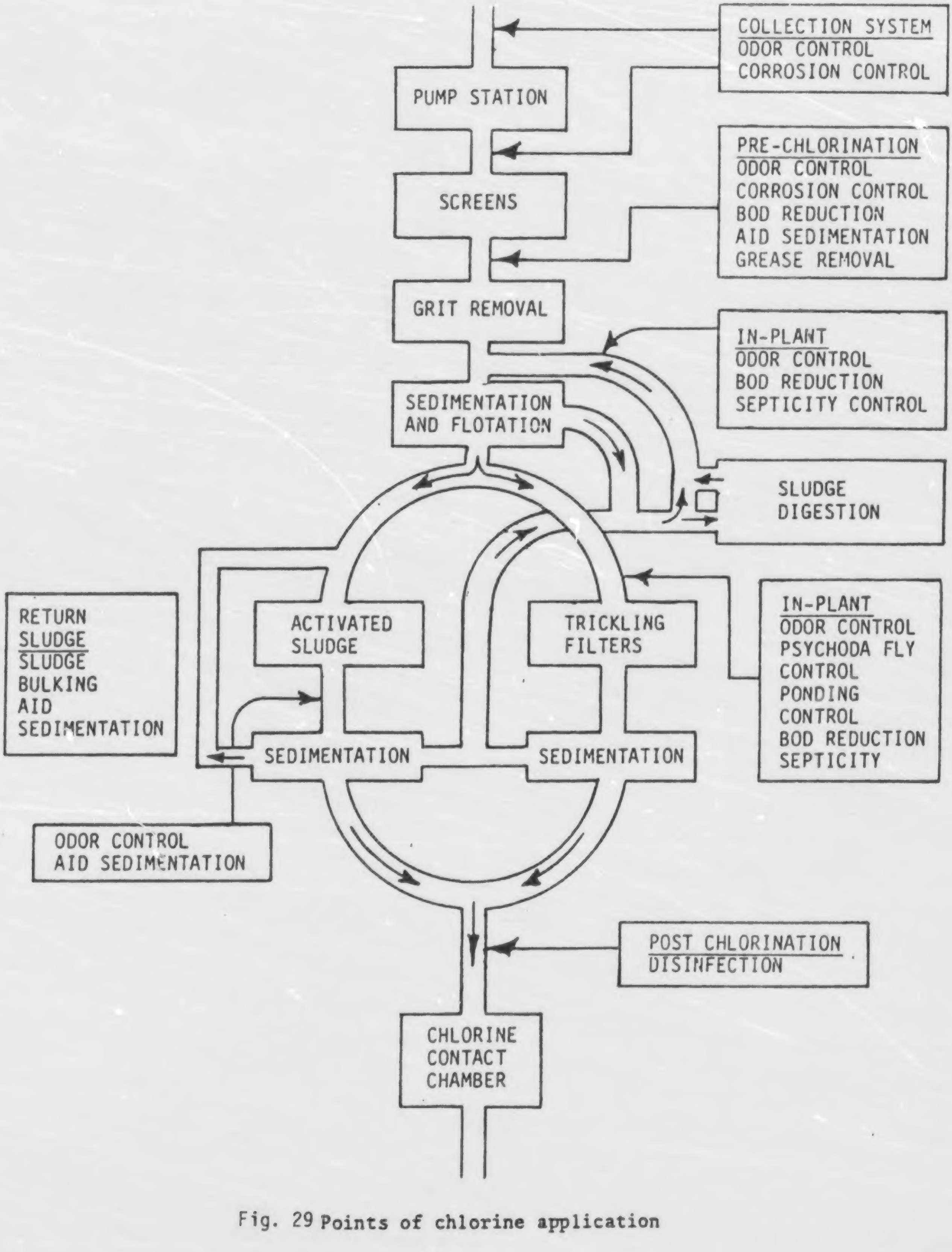

COLLECTION SYSTEM
ODOR CONTROL
CORROSION CONTROL
PUMP STATION
PRE-CHLORINATION
ODOR CONTROL
CORROSION CONTROL
BOD REDUCTION
AID SEDIMENTATION
GREASE REMOVAL
SCREENS
GRIT REMOVAL
IN-PLANT
ODOR CONTROL
BOD REDUCTION
SEPTICITY CONTROL
SEDIMENTATION AND FLOTATION
SLUDGE DIGESTION
RETURN SLUDGE
SLUDGE BULKING
AID SEDIMENTATION
ACTIVATED SLUDGE
TRICKLING FILTERS
IN-PLANT
ODOR CONTROL
PSYCHODA FLY CONTROL
PONDING CONTROL
BOD REDUCTION
SEPTICITY
SEDIMENTATION
SEDIMENTATION
ODOR CONTROL
AID SEDIMENTATION
POST CHLORINATION
DISINFECTION
CHLORINE CONTACT CHAMBER

Fig. 29 **Points of chlorine application**

VI VISUAL AIDS

Two excellent sources of visual aids are available if you wish to use visual aids in the teaching of this course. For details see:

1. Water Quality Control Instructional Materials

   Obtain from:

   National Training and Operational Technology Center
   U. S. Environmental Protection Agency
   Cincinnati, Ohio 45268

2. Journal Water Pollution Control Federation, Annual March Issue, Part II

   Obtain from:

   Water Pollution Control Federation
   2626 Pennsylvania Avenue, N.W.
   Washington, D.C. 20037

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VII SAMPLE QUESTIONS AND ANSWERS

FOR

EXAMS AND FINAL

SAMPLE QUESTIONS AND ANSWERS
FOR
EXAMS AND FINAL

This section contains sample questions and answers for exams and final. The intent is to provide you with typical job related exam questions and answers. Please feel free to make up your own questions to test your students on material you believe they need to know to do their jobs.

True-false, multiple choice, arithmetic problems and essay questions and answers are provided. Questions listed under Exams I, II, and III may be used for the final exam. Some questions listed under the final exam attempt to test the student's ability to apply knowledge and skills learned during the entire semester. Consideration must be given at this time for those topics that will be covered during the next course, Wastewater Treatment II.

The type and number of questions should be selected by the instructor.

SAMPLE QUESTIONS

EXAM I

Chapter 1.	The Treatment Plant Operator
Chapter 2.	Why Treat Wastes?
Chapter 3.	Wastewater Facilities
Chapter 4.	Racks, Screens, Comminutors and Grit Removal

A. True - False Questions

1. If wastewater has a pH of 5.5, it would have basic characteristics.
2. A grit chamber with a slower flow velocity than recommended may allow appreciable organic matter to settle out with the grit.
3. In some wastewater treatment plants, the operator may be a "jack of all trades."
4. Visttorsto a wastewater treatment plant are influenced most by neat, accurate operation and maintenenace records, not by the appearance of the plant and grounds.
5. Disease causing bacteria may be called pathogens.
6. Aerobic bacteria do not need oxygen.
7. Hydrogen sulfide gas is released by anaerobic bacteria.
8. Solids in wastewater are all organic.
9. A trickling filter removes solids by a filtering action.
10. Settled solids from a sedimentation tank are called sludge.
11. Both the trickling filter and activated sludge treatment processes are aerobic biological treatment processes.
12. The activated sludge process uses large amounts of air (oxygen).

13. Most wastewater treatment ponds have both aerobic and anaerobic treatment processes going on at the same time.

14. A high BOD plant effluent is good.

15. Septic wastewater looks black and smells bad.

16. Wastewater treatment plant operators should always wash their hands before smoking or eating to prevent becoming infected with water-borne diseases.

17. Raw wastewater is plant effluent before any treatment.

18. Velocity of wastewater flowing through a grit channel affects the efficiency of grit removal.

19. Burial in an approved sanitary landfill is an acceptable method of grit disposal.

20. Slipping and falling is one of the major safety hazards encountered by operators.

B. Multiple Choice Questions (Select the one best answer)

NOTE: In the objective tests in Operation of Wastewater Treatment Plants, students are instructed to select the correct answers (there may be more than one correct answer). In this Instructor's Manual, students should select the best answer (there is only one correct answer). Students should learn to take different types of exams and to read the directions.

1. The results of measurements for settleable solids in wastewater samples are reported in:
   1. ppm
   2. mg/l
   3. ml/l
   4. lbs/cu ft
   5. kg/cu m

2. An example of receiving waters is
    1. a stream
    2. a river
    3. a lake
    4. the ocean
    5. all of the above
3. An operator of a wastewater treatment plant may work for
    1. a city
    2. a sanitation district
    3. an industry
    4. any of the above
4. Which one of the following is a biological treatment process?
    1. Flow measurement
    2. Comminuting
    3. Grit removal
    4. Trickling filtration
    5. Sedimentation
5. Pretreatment of wastewater involves:
    1. Pumping, grit removal, comminution
    2. Grit removal, sedimentation, flow measurement
    3. Screening, grit removal, preaeration
    4. Shredding, sedimentation, filtering
    5. Screening, sedimentation, disinfection

6. Bar racks remove
    1. Grit
    2. Large objects and debris
    3. Scum
    4. Floatables
    5. Organic solids
7. Grit is composed mainly of
    1. Grease and scum
    2. Sludge and organic materials
    3. Hair and plastic goods
    4. Sand and egg shells
    5. Floating wood and paper
8. What should be done first by a wastewater treatment plant operator before starting to work on a mechanically cleaned screen?
    1. Decide what to do with the screenings
    2. Find secure footing
    3. Start cleaning screens with a rake
    4. Contact supervisor
    5. Turn off, lock out and properly tag electrical power switch to screen drive motor
9. If you observed an unusually high difference between the upstream and downstream water surface at a bar screen, the problem could be caused by
    1. Water flowing over the channel
    2. The bar screen being clogged
    3. Bars missing
    4. Bar screen not vertical
    5. Solids settling upstream from the bar screen

10. What could be the cause of solids passing through a comminutor without being cut or shredded?

 1. Screen bars broken
 2. Improper cutting adjustment
 3. Base seal broken
 4. Too many solids in influent
 5. Stationary cutters chipped

C. Arithmetic Questions

1. A stick travels 60 feet in a grit channel in 40 seconds. Estimate the velocity in the grit channel.
2. A wastewater treatment plant has an average flow of 1.5 MGD. An average of 4.5 cu ft of grit is removed each day. How many cu ft of grit per MG of flow are removed?

D. Essay Questions

1. How would you attempt to find a job as a wastewater treatment plant operator?

SAMPLE QUESTIONS

EXAM II

Chapter 5. Sedimentation and Flotation

Chapter 6. Trickling Filters

Chapter 7. Rotating Biological Contactors

A. True - False Questions

1. In a rectangular settling tank, each wooden flight is equipped with wearing shoes.
2. Septic conditions may develop rapidly during warm weather in primary clarifiers if sludge is not removed at regular intervals.
3. Gas bubbles rising to the surface in a primary clarifier are normally an indication that the sludge in the unit is undergoing proper settling.
4. Wastewater may be applied to a trickling filter bed by either fixed spray nozzles or by rotary distributors.
5. A trickling filter is used to filter out suspended organic solids contained in wastewater.
6. The intentional flooding of filter media with wastewater is sometimes effective in killing filter flies.
7. The biological growth on trickling filter media is composed principally of aerobic forms of bacteria, fungi, algae, protozoa, worms and the larvae of insects.
8. A trickling filter provides higher BOD removal in cold weather than in hot weather.
9. The spaces or voids between trickling filter media need to remain open to permit the free flow of air throughout the bed.

10. When the velocity varies in different areas of a rectangular sedimentation tank, "short circuiting" may occur.

11. Sludge withdrawal from clarifiers should be at a rate which prevents pulling too much water with the sludge.

12. Temperature of the influent wastewater has little influence on the settling of sludge in a clarifier.

13. Particles settle out in a clarifier from the effluent straight down to the bottom of the tank.

14. A sludge pump pumping a thick sludge will sound different than when pumping a thin sludge.

15. Samples taken from a clarifier for testing to determine clarifier removal efficiencies need to be taken only at the effluent or discharge pipe.

16. Floating chunks of sludge indicate good flotation in a clarifier.

17. Sludge gasification means pumping air into the sludge.

18. Drowning is a constant hazard for operators working in wastewater treatment plants.

19. A trickling filter is a physical method of treating wastewater.

20. Trickling filter media are all naturally occurring rock material.

21. Trickling filter slime is called zoogleal film in a trickling filter.

22. Masking agents are used to cover trickling filter media.

23. Colloidal solids in wastewater settle out in clarifiers after about 4 hours.

24. Temperature has little impact on the performance of a trickling filter.

25. The efficiency of a trickling filter may be improved by recirculating treated wastewater back through the trickling filter.

26. Odors can be a guide to how poorly or properly a trickling filter is operating.

B. Multiple Choice Questions

1. The shear pin in a primary clarifier drive unit:
    1. Cuts rags, paper and debris
    2. Aids in the removal of oil and grease
    3. Indicates proper oil level
    4. Is not replaceable
    5. Will break at a certain stress
2. Primary sludge which is reported as 6 percent solids by weight has an equivalent solids concentration of:
    1. 6 mg/l
    2. 6,600 mg/l
    3. 60,000 mg/l
    4. 600,000 mg/l
    5. None of the above
3. Natural ventilation in a trickling filter occurs when:
    1. The gelatinous organic films formed on the media are sloughed off.
    2. The action of the dosing siphon is ineffective
    3. The trickling filter is hydraulically overloaded
    4. The temperature of the wastewater is different than the temperature of the air
    5. None of the above
4. Secondary or final clarifiers are needed to
    1. Provide chlorine contact time
    2. Increase sludge digestion processes
    3. Increase septic conditions
    4. Remove solids from biological processes
    5. Provide essential nutrients for micro-organisms treating wastes

5. Which of the following is NOT a dangerous gas encountered by operators in and around wastewater treatment plants?
    1. Chlorine
    2. Nitrogen
    3. Hydrogen sulfide
    4. Methane
    5. Hydrocarbon vapors
6. An operator usually determines if a "thin" sludge is being pumped by the
    1. Feel of the sludge
    2. Smell of the sludge
    3. Color of the sludge
    4. Sound of the sludge pump
    5. Speed of the sludge scrapers
7. If hydraulic short circuiting is causing problems in a clarifier, the operator should
    1. Change pump, disconnect switch fuses
    2. Flip the circuit breakers
    3. Restart the pumps
    4. Reset the circuit breakers
    5. Try installing baffles
8. Which of the following is NOT an indication of poor clarifier performance
    1. High BOD in effluent
    2. High settleable solids in effluent
    3. High pH in effluent
    4. Floating chunks of sludge on surface
    5. Gas bubbles rising to surface

9. Given the following information for a primary sedimentation tank:

    1. Raw sludge pumps run 10 minutes during each hour
    2. Raw sludge has 7 percent total solids at start of pumping cycle and 5 percent total solids at end of cycle
    3. Sludge collectors run continuously.

    How could the problem of a deep sludge accumulation over the entire tank bottom be corrected?

    1. Decrease raw sludge pumping cycles
    2. Increase raw sludge pumping cycles
    3. Decrease running time of sludge collectors
    4. Increase running time of sludge collectors
    5. Increase size of sludge hopper

10. Given the same information as problem 9 except that the raw sludge has 3 percent total solids at start of pumping cycle and 2 percent solids at end of pumping cycle. Which of the answers listed for problem 9 is correct?

11. Given the following information regarding a trickling filter:

    1. Media is uniformly sized and not disintegrating;
    2. Media surface is free of debris;
    3. Organic loading has increased; and
    4. No change in hydraulic loading.

    What could be the cause of ponding on the filter surface?

    1. Decrease in filter ventilation
    2. Decrease in temperature
    3. Improper distribution of wastewater over filter
    4. Increased biological growth on media
    5. Chlorination rate to filter too high

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C. Arithmetic Questions

1. A flow of 1.0 MGD is applied to a 50-foot diameter trickling filter. Calculate the hydraulic loading on the filter in gpd/sq ft.
2. A plant influent of 4 MGD contains 250 mg/l BOD. How may pounds of BOD enter the plant each day?
3. Find the volume (cu ft and gallons) of a circular sedimentation tank 60 feet in diameter and 10 feet deep.
4. Find the detention time in a rectangular sedimentation tank 15 feet deep, 20 feet wide and 100 feet long when the flow is 3 MGD.
5. The influent to a trickling filter plant contains 320 mg/l suspended solids. The final effluent contains an average of 30 mg/l suspended solids. What is the overall efficiency for removing suspended solids?
6. A trickling filter plant receives an average flow of 280,000 gpd with an average BOD of 170 mg/l. If the primary sedimentation tank removes 40 percent of the influent BOD, what is the organic loading applied to the trickling filter (lbs BOD/day/1000 cu ft) if it has a 25-foot diameter and a media depth of 4 feet.
7. A plant that treats 2.1 MGD by primary sedimentation (before activated sludge with gravity thickeners) removes 40 percent of the influent suspended solids. If the suspended solids concentration in the raw wastewater is 300 mg/l, how many gallons of sludge at 5 percent solids should be pumped to the digester daily?

D. Essay Questions

1. What is the purpose of primary clarification?
2. Prepare a check list of items you would check if lab results showed a drop in primary clarifier efficiency.
3. What could cause a shock load on a trickling filter?

SAMPLE QUESTIONS

EXAM III

Chapter 8.	Activated Sludge (Extended Aeration and Oxidation Ditches)
Chapter 9.	Waste Treatment Ponds
Chapter 10.	Disinfection and Chlorination

A. True - False Questions

1. Chlorine is sometimes added to the influent of a plant for odor control.
2. Disinfection is usually defined as the killing of pathogenic organisms.
3. Temperature, DO, and pH are important indicators of the condition of oxidation ponds.
4. A pond depth of at least 8 feet is recommended to prevent tule or cattail growth.
5. A disadvantage of excessive depth in an oxidation pond is that not enough sunlight will reach the bottom layers of wastewater in the pond.
6. In the activated sludge process, effluent must be continuously returned from the final settling tanks to the aeration tanks.
7. A disadvantage of excessive scum on an oxidation pond is that the scum will interfere with photosynthesis.
8. Oxidation pond effluents are easily disinfected with chlorine because of the large amount of algae present.
9. Ranges of treatment efficiencies that can be expected from ponds vary more than most other treatment processes.
10. The organic loading on a wastewater lagoon is higher than on a polishing pond.
11. The contents of an aeration tank used in the activated sludge treatment process is referred to as mixed liquor.

12. Cannister-type gas masks should not be used to repair chlorine leaks because this type of mask is ineffective in oxygen deficient atmospheres.

13. Disinfection can be accomplished by a process that will create a toxic environment for pathogenic organisms.

14. An activated sludge process is similar to a clarifier process.

15. The extended aeration process and the oxidation ditch process treat wastes by similar waste treatment processes.

16. The operator of an activated sludge process must control aeration rates.

17. Oxygen is necessary for the growth of inorganic activated sludge.

18. Hydraulic loadings are not a problem in activated sludge plants.

19. BOD loadings are not a problem in activated sludge plants.

20. An increase in inorganic suspended solids in the mixed liquor improves the reduction of BOD in the plant effluent.

21. "Food" for an activated sludge process is part of the plant effluent.

22. A package activated sludge plant does not need a clarifier.

23. A facultative pond treats wastes under both aerobic and anaerobic conditions.

24. A scum raft is a piece of equipment.

25. Effluent should leave a waste treatment pond just below the water surface.

26. Influent should be added to a waste treatment pond below the water surface.

27. Operation of a waste treatment pond does not require expensive equipment.

28. Anaerobic ponds require a great deal of DO.

29. Chlorine is added to wastewater only by automatically controlled valves, meters and pumps.

30. Chlorine is toxic.

31. Chlorine is an irritant to breathing organs of the body.

32. Knowledge of first aid is important for a competent operator.

33. Effectiveness of disinfection depends on how long chlorine is in contact with the wastewater.

34. Effectiveness of disinfection depends on how well chlorine is mixed with the wastewater.

35. Leaking chlorine cylinders may be shipped if properly tagged.

36. Hydrogen sulfide smells like chlorine.

37. Post chlorination generally is more effective in a well-clarified effluent than in a turbid effluent.

38. Wastewater treatment plant effluent must be sterilized in order to protect downstream users of receiving waters.

39. Disease producing bacteria are called saprophygenic.

40. Cannister-type "gas masks" are usually inadequate and ineffective protection for the wearer when repairing chlorine leaks. (Similar to question 12).

B. Multiple Choice Questions

1. What is the chlorine demand of an effluent if the chlorine dosage is 10.0 mg/l and the residual is 2.0 mg/l?
    1. 20 mg/l
    2. 12 mg/l
    3. 10 mg/l
    4. 8 mg/l
    5. 5 mg/l
2. Algae in an aerobic or facultative wastewater stabilization pond aid treatment by:
    1. Breaking down the carbonaceous wastes entering the pond system
    2. Feeding on the bacteria and other micro-organisms present in the wastewater.
    3. Supplying oxygen for the bacteria involved in treatment.
    4. Improving the aesthetic appearance of the pond because of their green color.
    5. None of the above.
3. Introducing oxygen into wastewater using surface aerators is primarily used in:
    1. Grit channels
    2. Trickling filters
    3. Chlorine contact chambers
    4. Wet wells
    5. Activated sludge systems

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4. Biological activity in a wastewater treatment pond is dependent on which of the following factors?
    1. Sunlight
    2. Temperature
    3. Dissolved oxygen
    4. Nutrients
    5. All of the above
5. The amount of chlorine contained in a cylinder or tank is usually determined by
    1. Pressure gage
    2. Rotameter
    3. Weighing
    4. Temperature differentials
    5. None of the above
6. The ultimate measure of the effectiveness of chlorination in disinfection is:
    1. The measurement of chlorine dosage
    2. Meeting the chlorine demand of the water
    3. The establishment of a chlorine residual
    4. Effective reduction of the coliform count
    5. None of the above
7. Ponds that are used in series after a trickling filter plant are most commonly referred to as:
    1. Polishing ponds
    2. Denitrification ponds
    3. Oxidation ponds
    4. Anaerobic ponds
    5. Digestion ponds

8. Which one of the following laboratory tests is used to calculate both loading and efficiencies in wastewater treatment ponds?
    1. pH
    2. Dissolved oxygen (DO)
    3. Methylene blue test
    4. Coliform MPN
    5. Biochemical oxygen demand (BOD)
9. When collecting a sample for a chlorine residual determination of the final effluent, the most suitable sampling point is:
    1. At the site of chlorine injection
    2. At the entrance to the chlorine contact chamber
    3. At the midpoint of the chlorine contact chamber
    4. At the exit side of the chlorinator
    5. At the point of discharge
10. When applying chlorine for disinfection, which of the following is not normally an operational consideration?
    1. Mixing
    2. DO
    3. Contact time
    4. pH
    5. Suspended solids
11. The activated sludge treatment process is
    1. A chemical process
    2. A physical process
    3. A biological process
    4. An anaerobic process
    5. An endogenous process

12. When return activated sludge (RAS) from the clarifier to the aerator is too low:

    1. The aerator will not fill
    2. The activated sludge will starve
    3. Too few micro-organisms will be available to treat the wastes
    4. The MLVSS will be too high
    5. The sludge blanket in the aerator will be too high

13. Which of the following is NOT a main operational control in an activated sludge plant

    1. Primary effluent suspended solids
    2. Aeration rate
    3. Return sludge rate
    4. Chlorination rate
    5. Pounds of solids under aeration

14. An important operation and maintenance aspect of waste treatment ponds is

    1. Channeling
    2. Odors
    3. Coning
    4. Bulking
    5. Clarification

15. Facultative ponds are

    1. Anaerobic
    2. Aerobic
    3. Aerobic at the top and anaerobic at the bottom
    4. Anaerobic at the top and aerobic at the bottom
    5. None of the above

16. Lab samples from a waste treatment pond are taken daily to test for:

    1. Suspended solids
    2. Sunlight penetration
    3. Coliform bacteria
    4. Dissolved solids
    5. Dissolved oxygen

17. Waste treatment pond loadings may be expressed in

    1. Inches of depth added per day
    2. Persons per acre
    3. Pounds of BOD added per day per acre
    4. Any of the above
    5. None of the above

18. Chlorine demand equals

    1. Chlorine dose
    2. Chlorine applied plus chlorine residual
    3. Chlorine applied minus chlorine residual
    4. Chlorine loading plus chlorine residual
    5. Chlorine loading minus chlorine residual

19. Chlorine is commonly applied to wastewater from the chlorinator

    1. As chlorine gas
    2. As liquid chlorine
    3. As chlorine pellets
    4. As a solution of chlorine or chlorine compound and water
    5. As a slurry of chlorine compound and water

20. Chlorination should be provided
    1. For about 30 minutes each hour
    2. When needed
    3. Periodically, but based on demand
    4. Continuously
    5. When the effluent is tested
21. Given the following information regarding a chlorination system that is unable to meet the chlorine demand.
    1. Chlorine pressure at chlorinater is low
    2. Frost on chlorine supply lines
    3. Frost on chlorine cylinder
    4. Frost goes away and chlorine pressure at chlorinator goes up when feed rate is cut down.

    Why can't chlorinator meet chlorine demand?
    1. Chlorine demand is greater than maximum possible feed rate
    2. Chlorine supply line is clogged
    3. Pressure reducing valve is clogged
    4. Broken dip tube inside chlorine container
    5. Insufficient injector water
22. Given the following information regarding an extended aeration package plant:
    1. Blower normal
    2. Normal dry weather flow
    3. DO level suddenly low, but stable
    4. Drop pipe control valve half open
    5. Surface turbulence inadequate
    6. Influent wastewater characteristics normal and unchanged
    7. When drop pipe air control valves are fully opened, DO level and surface

turbulence stay unchanged.

What could have caused the sudden drop in DO level?

1. Drop pipes clogged
2. Air header pipe partly clogged
3. Aeration time too long
4. Air control valves not opened enough
5. Too few organics in the influent wastewater

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C. Arithmetic Questions

1. If the chlorine dosage must be 10 mg/l when the flow is 0.7 MGD, determine the chlorine feed rate in pounds per day.
2. A chlorinator is set to feed 60 pounds of chlorine per day to a flow of 0.8 MGD. What is the chlorine dosage in mg/l?
3. How may pounds of HTH (high-test hypochlorite, 65 percent available chlorine) would be required to provide a dosage of 15 mg/l to a flow of 70,000 gallons per day?
4. What rotameter setting should be used to apply a 9 mg/l dose of chlorine to a flow of 1000 GPM?

A pond receives an inflow of 0.025 MGD from 300 people. The pond is 300 feet long, 150 feet wide, and 4 feet deep. The influent BOD is 180 mg/l. Determine the following loading parameters:

5. Detention time in days.
6. Population loading in persons per acre
7. Hydraulic loading in inches per day
8. Organic loading in pounds of BOD applied per day per acre.

D. Essay Questions

1. What observations might lead you to believe that a toxic waste has hit your extended aeration or oxidation ditch treatment plant?
2. You are the operator of a waste treatment pond serving a small city. The mayor has received numerous odor complaints and asked you to correct the situation. What would you do?
3. Recently the effluent from your treatment plant has had MPN coliform counts over those allowed by your NPDES permit. How would you correct this situation?

SAMPLE QUESTIONS

FINAL EXAM

Remember that the other three exams also contain good questions for the final.

A. True - False Questions

1. The main purpose of secondary sedimentation tanks is to settle out sand and grit from the raw wastewater.
2. Sanitary wastewater is commonly considered to be the same as disinfected domestic sewage.
3. Air temperature and weather are a concern in the operation of wastewater treatment plants.
4. Many wastewater treatment plant operators have been seriously injured due to avoidable accidents.
5. When draining a tank, the groundwater level should be down far enough so that the tank will not float or rupture while empty.
6. Grease removal in a primary clarifier can be improved by first aerating the wastewater.

B. Multiple Choice Questions

1. What is the first precaution in repairing electrical equipment?
    1. Wear rubber gloves and use insulated tools.
    2. Put out all cigarettes
    3. Throw the circuit breakers, lock it out and properly tag it.
    4. Call the power company
    5. Mop up any water that might be on the floor.

2. What problems can be caused when excessive storm water enters a treatment plant?
   1. Reduced treatment time
   2. Increased grit and silt
   3. Increased hydraulic loading
   4. Fluctuations in temperature and solids content
   5. All of the above

C. Arithmetic Questions

NONE

D. Essay Questions

NONE

ANSWERS FOR SAMPLE QUESTIONS IN EXAM I

Chapter 1. The Treatment Plant Operator

Chapter 2. Why Treat Wastes?

Chapter 3. Wastewater Facilities

Chapter 4. Racks, Screens, Comminutors and Grit Removal

A. True - False Answers

1. F
2. T
3. T
4. F
5. T
6. F
7. T
8. F
9. F
10. T
11. T
12. T
13. T
14. F
15. T
16. T
17. F
18. T
19. T
20. T

B. Multiple Choice Answers

1.	3	6.	2
2.	5	7.	4
3.	4	8.	5
4.	4	9.	2
5.	3	10.	2

C. Arthmetic Solutions

1. Known	Unknown
Distance, ft = 60 ft	Velocity, ft/sec
Time, sec = 40 sec	

Determine velocity in ft/sec

$$\text{Velocity, ft/sec} = \frac{\text{Distance traveled, ft}}{\text{Time, sec}}$$

$$\text{Velocity, ft/sec} = \frac{60 \text{ ft}}{40 \text{ sec}}$$

$$= 1.5 \text{ ft/sec}$$

2. Known	Unknown
Flow, MGD = 1.5 MGD	Grit, cu ft/MG
Grit, cu ft/day = 4.5 cu ft/day	

Determine grit removed in cu ft grit per MG

Wastewater treated.

$$\text{Grit, cu ft/MG} = \frac{\text{Grit, cu ft/day}}{\text{Flow, MGD}}$$

$$\text{Grit, cu ft/MG} = \frac{4.5 \text{ cu ft/day}}{1.5 \text{ MG/day}}$$

$$= 3.0 \text{ cu ft/MG}$$

D. Essay Answers

Student should discuss the following topics:

1. Prepare for job by education
2. Determine location of wastewater treatment plants.
3. Talk to operators regarding job opportunities
4. Contact personnel officers or plant managers to determine procedures and qualifications for applying for a job.

ANSWERS FOR SAMPLE QUESTIONS

IN EXAM II

Chapter 5.	Sedimentation and Flotation
Chapter 6.	Trickling Filters
Chapter 7.	Rotating Biological Contactors

A. True - False Answers

1. T
2. T
3. F
4. T
5. T
6. T
7. T
8. F
9. T
10. T
11. T
12. F
13. F
14. T
15. F
16. F
17. F
18. T
19. F
20. F
21. T
22. F
23. F
24. F

B. Multiple Choice Answers

1. 5
2. 3
3. 4
4. 2
5. 4
6. 4
7. 5
8. 3
9. 2
10. 1
11. 4

C. Arithmetic Solutions

1. **Known** | **Unknown**

Flow, MGD = 1.0 MGD — Hydraulic Loading, gpd/sq ft

Diameter, ft = 50 ft

Determine hydraulic loading in gallons per day per square foot

$$\text{Hydraulic loading, gpd/sq ft} = \frac{\text{Flow, gal/day}}{\text{Area, sq ft}} \qquad A = \frac{\pi}{4} D^2 = 0.785\ D^2$$

$$\text{Hydraulic loading, gpd/sq ft} = \frac{1{,}000{,}000\ \text{gal/day}}{0.785 \times 50\ \text{ft} \times 50\ \text{ft}}$$

$$= \frac{1{,}000{,}000\ \text{gal/day}}{1963.5\ \text{sq ft}}$$

$$= 509\ \text{gpd/sq ft}$$

2. **Known** | **Unknown**

Flow, MGD = 4 MGD — BOD, lbs/day

BOD, mg/l = 250 mg/l

Determine BOD loading in pounds per day

$$\text{BOD loading, lbs/day} = \text{Flow, MGD} \times \text{BOD, mg/l} \times 8.34\ \text{lbs/gal}$$

$$\text{BOD loading, lbs/day} = 4\ \text{MGD} \times 250\ \text{mg/l} \times 8.34\ \text{lbs/gal}$$

$$= \frac{4\ \text{M Gal}}{\text{day}} \times \frac{250\ \text{lbs BOD}}{\text{M lbs water}} \times \frac{8.34\ \text{lbs water}}{\text{gal}}$$

$$= 8{,}340\ \text{lbs/day}$$

3. Known — Unknown

Known	Unknown
Circular Sedimentation Tank	Tank Volume, cu ft
Diameter, ft = 60 feet	Tank Volume, gal
Depth, ft = 10 feet	

Determine tank volume in cubic feet and in gallons

$$\text{Tank Vol, cu ft} = \frac{\pi}{4} \times (\text{Diameter, ft})^2 \times \text{Depth, ft}$$

$$\text{Tank Vol, cu ft} = 0.785 \times 60 \text{ ft} \times 60 \text{ ft} \times 10 \text{ ft}$$

$$= 28{,}274 \text{ cu ft}$$

$$\text{Tan Vol, gal} = 28{,}274 \text{ cu ft} \times 7.48 \text{ gal/cu ft}$$

$$= 211{,}492 \text{ gal}$$

4.

Known	Unknown
Rectangular Sedimentation Tank	Detention Time, hr
Depth, ft = 15 ft	
Width, ft = 20 ft	
Length, ft = 100 ft	
Flow, MGD = 3 MGD	

Determine detention time for tank in hours.

$$\text{Detention Time, hrs} = \frac{\text{Tank Volume, M Gal} \times 24 \text{ hr/day}}{\text{Flow, MGD}}$$

$$\text{Detention Time, hrs} = \frac{100 \text{ ft} \times 20 \text{ ft} \times 15 \text{ ft} \times 7.48 \text{ gal/cu ft} \times 24 \text{ hr/day}}{3 \text{ MGD}}$$

$$= \frac{0.2244 \text{ M Gal} \times 24 \text{ hr/day}}{3 \text{ M Gal/day}}$$

$$= 1.8 \text{ hours}$$

5.

Known	Unknown
Infl. SS, mg/l = 320 mg/l	Overall efficiency, %
Effl. SS, mg/l = 30 mg/l	

Determine overall plant efficiency in removing suspended solids.

$$\text{Overall Efficiency, \%} = \frac{(\text{Infl. SS, mg/l} - \text{Effl. SS, mg/l}) \times 100\%}{\text{Infl. SS, mg/l}}$$

$$\text{Overall Efficiency, \%} = \frac{(320 \text{ mg/l} - 30 \text{ mg/l}) \times 100\%}{320 \text{ mg/l}}$$

$$= 90.6\%$$

6.

Known	Unknown
Flow, MGD = 0.28 MGD	Organic (BOD) Loading, lbs BOD/day/1000 cu ft
Infl. BOD, mg/l = 170 mg/l	
Primary Effl, % = 40%	
TF Diam., ft = 25 ft	
Depth, ft = 4 ft	

Determine organic (BOD) loading on trickling filter in lbs BOD applied per day per 1000 cu ft of media

$$\text{BOD Loading lbs BOD/day/1000 cu ft} = \frac{\text{Flow, MGD} \times \text{BOD, mg/l} \times \text{portion applied} \times 8.34 \text{ lbs/day}}{\text{Area, sq. ft.} \times \text{Depth, ft}}$$

$$\text{BOD Loading lbs BOD/day/1000 cu ft} = \frac{0.28 \text{ MGD} \times 170 \text{ mg/l} \times (1-0.4) \times 8.34 \text{ lbs/gal}}{(\pi/4) \times 25 \text{ ft} \times 25 \text{ ft} \times 4 \text{ ft}}$$

$$= \frac{0.28 \text{ MGD} \times 170 \text{ mg/l} \times 0.6 \times 8.34 \text{ lbs/gal}}{0.785 \times 25 \text{ ft} \times 25 \text{ ft} \times 4 \text{ ft}}$$

$$= \frac{238 \text{ lbs BOD/day}}{1.96 \text{ -- } 1000 \text{ cu ft}}$$

$$= 121 \text{ lbs BOD/day/1000 cu ft}$$

7. Known | Unknown

Flow, MGD = 2.1 MGD | Sludge Pumped, gallons/day

SS Removal, % = 40%

Infl. SS, mg/l = 300 mg/l

Sludge Solids, % = 5%

Determine gallons of primary sludge pumped per day to digester

$$\text{Sludge Pumped, gallons/day} = \frac{\text{Solids Removed, lbs/day}}{\text{Portion solids} \times 8.34 \text{ lbs/gal}}$$

$$= \frac{\text{Flow, MGD} \times \text{SS, mg/l} \times \text{Portion Removed} \times 8.34 \text{ lbs/gal}}{\text{Portion Solids} \times 8.34 \text{ lbs/gal}}$$

$$\text{Sludge Pumped, gallons/day} = \frac{2.1 \text{ MGD} \times 300 \text{ mg/l} \times 0.40 \times 8.34 \text{ lbs/gal}}{0.05 \times 8.34 \text{ lbs/gal}}$$

$$= \frac{2101 \text{ lbs solids/day}}{0.05 \times 8.34 \text{ lbs/gal}}$$

$$= 5{,}040 \text{ gallons/day}$$

D. Essay Answers

1. The purpose of primary clarification is to allow time for floatable and settleable material to float to the surface or settle to the bottom from the wastewater being treated.
2. If lab results showed a drop in primary clarifier efficiency, check
    1. Visual appearance of clarifier and effluent
    2. Any changes in influent flows or loadings
    3. Septic influent
    4. Operation of scrapers and skimmers
    5. Operation of sludge pumps
    6. Short circuiting
    7. Level of effluent weirs
    8. Sampling and testing program
3. A shock load on a trickling filter could be caused by hydraulic overloads, organic overloads or a toxic waste.

ANSWERS FOR SAMPLE QUESTIONS

IN EXAM III

Chapter 8.	Activated Sludge (Extended Aeration and Oxidation Ditches)
Chapter 9.	Waste Treatment Ponds
Chapter 10.	Disinfection and Chlorination

A. True - False Answers

1. T
2. T
3. T
4. F
5. T
6. F
7. T
8. F
9. T
10. T
11. T
12. F
13. T
14. F
15. T
16. T
17. F
18. F
19. F
20. F
21. F
22. F
23. T
24. F
25. T
26. T
27. T
28. F
29. F
30. T
31. T
32. T
33. T
34. T
35. F
36. F
37. T
38. F
39. F
40. T

B. Multiple Choice Answers

1. 4
2. 3
3. 5
4. 5
5. 3
6. 4
7. 1
8. 5
9. 5
10. 2
11. 3
12. 3
13. 4
14. 2
15. 3
16. 5
17. 4
18. 3
19. 4
20. 4
21. 1
22. 2

C. Arithmetic Solutions

1. Known

Chlorine dose, mg/l = 10 mg/l

Flow, MGD = 0.7 MGD

Unknown

Chlorine feed rate, lbs/day

Calculate the chlorine feed rate in pounds of chlorine per day.

Chlorine feed rate, lbs/day = Flow, MGD x Dose, mg/l x 8.34 lbs/gal

Chlorine feed rate, lbs/day = 0.7 MGD x 10 mg/l x 8.34 lbs/gal

= 58.4 lbs/day

2. Known

Chlorine feed rate, lbs/day = 60 lbs/day

Flow, MGD = 0.8 MGD

Unknown

Chlorine dose, mg/l

Determine chlorine dose in mg/l

$$\text{Chlorine dose, mg/l} = \frac{\text{Chlorine feed rate, lbs/day}}{\text{Flow, MGD} \times 8.34 \text{ lbs/gal}}$$

$$\text{Chlorine dose, mg/l} = \frac{60 \text{ lbs/day}}{0.8 \text{ M Gal/day} \times 8.34 \text{ lbs/gal}}$$

= 9 lbs/M lbs

= 9 mg/M mg

= 9 mg/l

3. Known

HTH, 65 % available chlorine

Dose, mg/l = 15 mg/l

Flow, gpd = 70,000 gpd

Unknown

HTH, lbs/day

Determine HTH required in pounds per day

$$\text{HTH, lbs/day} = \frac{\text{Flow, MGD} \times \text{Dose, mg/l} \times 8.34 \text{ lbs/gal}}{\text{Portion HTH}}$$

$$\text{HTH, lbs/day} = \frac{0.07 \text{ MGD} \times 15 \text{ mg/l} \times 8.34 \text{ lbs/gal}}{0.65}$$

$$= 13.5 \text{ lbs HTH/day}$$

4. Known

Dose, mg/l = 9 mg/l

Flow, GPM = 1000 GPM

Unknown

Dose, lbs/day

Determine rotameter setting in pounds of chlorine per day

$$\text{Dose, lbs/day} = \text{Flow, MGD} \times \text{Dose, mg/l} \times 8.34 \text{ lbs/gal}$$

$$\text{Dose, lbs/day} = \frac{1000 \text{ GPM} \times 9 \text{ mg/l} \times 8.34 \text{ lbs/gal}}{694 \text{ GPM/MGD}}$$

$$= 108.2 \text{ lbs/day}$$

$$= 110 \text{ lbs day for setting}$$

5., 6., 7., and 8

Known

Flow, MGD = 0.025 MGD

Population, persons = 300 persons

Length, ft = 300 feet

Width, ft = 150 feet

Depth, ft = 4 feet

Infl. BOD, mg/l = 180 mg/l

Unknown

5. Detention Time, days
6. Population Loading, persons/acre
7. Hydraulic Loading, inches/day
8. Organic Loading, lbs BOD/day/acre

1. Calculate the pond area in acres

$$\text{Pond Area, ac} = \frac{\text{Width, ft} \times \text{Length, ft}}{43{,}560 \text{ sq ft/ac}}$$

$$\text{Pond Area, ac} = \frac{150 \text{ ft} \times 300 \text{ ft}}{43{,}560 \text{ sq ft/ac}}$$

$$= 1.03 \text{ ac}$$

2. Calculate pond volume in acre feet.

$$\text{Pond Vol., ac-ft} = \text{Area, ac} \times \text{Depth, ft}$$

$$\text{Pond vol., ac-ft} = 1.03 \text{ ac} \times 4 \text{ ft}$$

$$= 4.12 \text{ ac-ft}$$

3. Convert influent flow to ac-ft/day

$$\text{Flow, ac-ft/day} = \frac{\text{Flow, gal/day}}{7.48 \text{ gal/cu ft} \times 43{,}560 \text{ sq ft/ac}}$$

$$\text{Flow, ac-ft/day} = \frac{25{,}000 \text{ gal/day}}{7.48 \text{ gal/cu ft} \times 43{,}560 \text{ sq ft/ac}}$$

$$= 0.0767 \text{ ac-ft/day}$$

Problem No. 5

Determine detention time in days.

$$\text{Detention Time, days} = \frac{\text{Pond Volume, ac-ft}}{\text{Flow, ac-ft/day}}$$

$$\text{Detention Time, days} = \frac{4.12 \text{ ac-ft}}{0.0767 \text{ ac-ft/day}}$$

$$= 54 \text{ days}$$

322

Problem No. 6

Determine population loading in persons per acre.

$$\text{Population Loading, Persons/acre} = \frac{\text{Population Served, persons}}{\text{Pond Area, acres}}$$

$$\text{Population Loading, Persons/acre} = \frac{\text{300 persons}}{\text{1.03 acres}}$$

$$= \text{291 persons/acre}$$

Problem No. 7

Determine hydraulic loading in inches per day.

$$\text{Hydraulic Loading, inches/day} = \frac{\text{Pond Depth, in}}{\text{Detention time, days}}$$

$$\text{Hydraulic Loading, inches/day} = \frac{\text{4 ft} \times \text{12 in/ft}}{\text{54 days}}$$

$$= \text{0.89 inches/day}$$

Problem No. 8

Determine organic loading in pounds of BOD applied per day per acre.

$$\text{Organic Loading , lbs BOD/day/ac} = \frac{\text{Flow, MGD} \times \text{BOD, mg/l} \times \text{8.34 lbs/gal}}{\text{Pond Area, ac}}$$

$$\text{Organic Loading , lbs BOD/day/ac} = \frac{\text{0.025 MGD} \times \text{180 mg/l} \times \text{8.34 lbs/gal}}{\text{1.03 acres}}$$

$$= \frac{\text{37.53 lbs BOD/day}}{\text{1.03 acres}}$$

$$= \text{36.4 lbs BOD/day/ac}$$

D. Essay Answers

1. Toxic waste hits plant
    1. Solids in effluent
    2. Change in color of mixed liquor or influent
    3. Change in influent and effluent pH
    4. Change in results of settleability tests (settling rates or amount of settleable solids).
2. Pond odors

    Try to find source or causes of odors

    1. Scum rafts
    2. Lack of DO in pond (check early morning DOs)
    3. Organic (BOD) overload
    4. Look for possible sources of odors other than pond (try manholes, lift stations, and livestock feeding areas).
3. Failure to meet NPDES MPN coliform counts. Look for cause of ineffective disinfection
    1. Poor mixing of chlorine with wastewater being treated
    2. Insufficient contact time due to short circuiting or hydraulic overloads
    3. Solids in effluent
    4. Solids on bottom of chlorine contact basin
    5. Inadequate chlorine dose

ANSWERS FOR SAMPLE QUESTIONS

FINAL EXAM

A. True - False Answers

1. F
2. F
3. T
4. T
5. T
6. T

B. Multiple Choice Answers

1. 3
2. 5

C. Arithmetic Solutions

NONE

D. Essay Answers

NONE

VIII. OBJECTIVE TESTS AND ANSWERS

OBJECTIVE TEST

CHAPTER 1. INTRODUCTION

Please mark correct answers on IBM answer sheet.

1.1 The used water and solids from a community that flow to a treatment plant are called ______?

1. Effluent
2. Wastewater
3. Sewage
4. Mixed Liquor

1.2 Receiving water uses protected by an operator include:

1. Fishing
2. Boating
3. Drinking Water Supply
4. None of These

TRUE OR FALSE:

1.3 In many treatment plants the operator must be a "jack-of-all-trades".

1.4 A treatment plant operator is a water quality protector.

1.5 Plant visitors are impressed by records showing efficient plant operation, and their opinions are never influenced by the appearance of the plant and grounds.

1.6 After finishing this program, an operator will need to continue to study if he is to keep pace with changes occurring in the field.

Please write how long you worked on this chapter on your answer sheet.

OBJECTIVE TEST

Chapter 2. Why Treat Wastes?

Please write your name, date, city, time, instructor, and name of test on your answer sheet, then mark correct answers on answer sheet.

2.1 Wastes are treated to:

1. Prevent Pollution
2. Protect Human Health
3. Remove Harmful Wastes from Wastewater
4. Prevent Receiving Waters from Stinking

2.2 Diseases possibly spread by wastewater discharges include:

1. Typhoid
2. Cholera
3. Q Fever
4. Dysentery
5. Hepatitis (Jaundice)

2.3 Pathogenic bacteria are:

1. Inorganic
2. Disease Producing
3. Easy to See
4. Dissolved Gases
5. None of These

2.4 What does an Imhoff Cone measure?

1. Total Solids
2. Dissolved Solids
3. Settleable Solids
4. Organic Solids
5. Colloidal Solids

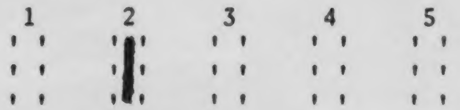
Match the definitions on the following page by placing the correct number from the column on the right in the proper space in front of the definition.

EXAMPLE

__2__ Milligrams per liter.

1. MPL
2. mg/l
3. MPN

Mark Column 2 on your answer sheet:



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continue test on next page

2.5 ________ Waste material which comes from animal or vegetable sources.

2.6 ________ Bacteria which will live and reproduce only in an environment containing dissolved oxygen.

2.7 ________ Bacteria which obtain their oxygen by breaking down chemical compounds which contain oxygen, such as sulfates (SO_4).

1. Organic Waste
2. Inorganic Waste
3. Radioactive Waste
4. Aerobic Bacteria
5. Anaerobic Bacteria

2.8 ________ Bacteria which can cause disease.

2.9 ________ A process which kills disease-causing bacteria.

2.10 ________ Any discharge of waste that reduces receiving water quality indicators below the established water quality standards.

1. Pollution
2. Disinfection
3. Nutrients
4. pH
5. Pathogenic Organisms

Please write how long you worked on this chapter on your answer sheet.

OBJECTIVE TEST

Chapter 3. Wastewater Facilities

Please mark correct answers in the proper columns on the IBM answer sheet, as directed at the end of Chapter 1. Return your answer sheet to your Project Director.

3.1 Name three different types of sewers.

1. Sanitary, Pipes, Storm
2. Sanitary, Storm, Conventional
3. Sanitary, Storm, Combined
4. Sanitary, Storm, Groundwater
5. Conventional, Surface, Combined

3.2 Combined sewers (1. are) or (2. are not) a problem to treatment plant operators.

3.3 The following are biological treatment processes.

1. Trickling Filters
2. Grit Removal
3. Digesters
4. Ponds
5. Shredders

3.4 The purpose of screening is:

1. Thin the Wastewater
2. Remove Large Objects and Debris
3. Grade the Solids into Different Sizes
4. Protect Public Health

3.5 Flow measurements are important because they are used to:

1. Determine Loading on Units
2. Determine Treatment Efficiency
3. Adjust Pumping Rates
4. Determine Chlorination Rates
5. Determine if a Plant is Handling its Design Capacity

3.6 The solids settled in a clarifier are called:

1. Dissolved Solids
2. Colloidal Solids
3. Emulsions
4. Sludge
5. Scum

3.7 The trickling filter (1. does) or (2. does not) remove solids by a filtering action.

3.8 Why is the digester gas mixed with air dangerous?

1. It will Explode
2. It Stinks
3. It Kills Grass

3.9 (1. Disinfection) or (2. Sterilization) is usually defined as the killing of pathogenic organisms, and

3.10 the killing of all organisms is called (1. disinfection) or (2. sterilization).

3.11 Ponds are capable of reducing:

1. Land Area and Cost
2. Mosquitoes and Weeds
3. BOD and Bacteria
4. Odors and Algae
5. None of these

Please write time required to work lesson on your answer sheet.

OBJECTIVE TEST

Chapter 4. Racks, Screens, Comminutors, and Grit Removal

Please mark correct answers on the answer sheet as directed at the end of Chapter 1. Return the answer sheet to your Program Director.

1. An operator must always wash his hands before eating or smoking to prevent becoming infected with a water-borne disease.
    1. True
    2. False
2. The following items may be found in a treatment plant influent.
    1. Cans
    2. Clothes
    3. Toys
    4. Rocks
    5. Eggshells
3. Detritus is a common name for skimmings.
    1. True
    2. False
4. Pretreatment may include a:
    1. Bar Screen
    2. Grit Chamber
    3. Detritus
    4. Flow Meter
    5. Clarifier
5. What should be done first if a problem develops in a mechanically cleaned screen?
    1. Reach in with your hand and fix the equipment.
    2. Attempt to fix the screen with the proper tools.
    3. Immediately identify problem and then turn off power if necessary or if problem can't be identified.
    4. Turn off the electrical power to the screen.
    5. Find someone to help in case you get into trouble.

6. The methods used to dispose of screenings include:

   1. Dumping into a nearby river
   2. Incineration
   3. Shredding or Grinding
   4. Selling for hog food
   5. Burial

7. Grit is composed of:

   1. Grease
   2. Sand
   3. Rubber Goods
   4. Eggshells
   5. Wood

8. A stick travels 30 feet in 20 seconds in a grit chamber. What is the flow velocity in the grit chamber?

   1. 0.5 ft/sec
   2. 0.67 ft/sec
   3. 1.0 ft/sec
   4. 1.5 ft/sec
   5. 2.0 ft/sec

Please write on your IBM answer sheet the total time required to work this chapter.

OBJECTIVE TEST

Chapter 5. Sedimentation and Flotation

Please write your name and mark the correct answers on the IBM answer sheet as directed at the end of Chapter 1. There may be more than one answer to each question.

EXAMPLE

The purpose of detaining water in a sedimentation tank is to:

1. Store for future use
2. Allow solids to settle to the bottom
3. Allow grease to float to the surface
4. Hold until trickling filter is ready
5. Provide chlorine contact time

To answer this question, you should mark on your answer sheet:

	1	2	3	4	5
EXAMPLE:	☐	■	■	☐	☐

---

1. Skimmed solids may be disposed of by:
   1. Pumping to digester
   2. Burying with material from bar screen
   3. Incineration
   4. Sold for grease and oil content
   5. None of these
2. What items should be checked before starting a clarifier?
   1. Remove debris from pipes and tank
   2. Lubricate equipment
   3. Sample effluent
   4. Turn off chlorinator
   5. Run a clarity test
3. Generally, pH is significantly affected by a clarifier:
   1. True
   2. False

4. An operator can tell if "thin" sludge is being pumped by:

   1. The sound of the sludge pump
   2. The smell of the sludge
   3. The color of the sludge
   4. Pressure gauge readings on the suction and discharge of the pump
   5. Visual observation

5. The maintenance program for a properly operating clarifier should include:

   1. Sample influent
   2. Regular inspection
   3. Keep a list of repairs
   4. Prompt adjustment or repair when necessary
   5. Lubricate equipment at regular intervals

6. Dangerous gases an operator may encounter in and around a treatment plant include:

   1. Hydrogen sulfide
   2. Nitrogen
   3. Chlorine
   4. Fumes from gasoline
   5. Methane

7. What factors influence the settling characteristics of solids in a clarifier?

   1. Flow velocity and/or turbulence
   2. Temperature
   3. Laboratory analyses
   4. Short circuiting
   5. Detention time

8. If short circuiting occurs in a clarifier, the operator should:

   1. Check the wiring
   2. Identify the cause
   3. Change fuses
   4. Try installing baffles
   5. Restart the pump

9. Plant analysis of samples is a reliable method of measuring clarifier efficiency:

   1. True
   2. False

10. What are "sloughings"?

   1. Troughs
   2. Slop
   3. Material washed off trickling filter media
   4. Waste activated sludge
   5. Grit

11. Secondary or final clarifiers are needed to:

   1. Increase sludge digestion
   2. Allow septic conditions to develop
   3. Provide a home for organisms
   4. Remove biological solids from wastewater
   5. None of these

12. An Imhoff tank has:

   1. Two compartments
   2. Sludge scrapers
   3. A piping system that may allow the flow in the tank to be reversed from one end to the other end
   4. A separate sludge digestion compartment under the settling area
   5. Gas vents

13. Primary clarifiers are designed to remove colloidal solids:

   1. True
   2. False

14. Estimate the detention time in a 20,000-gallon sedimentation tank if the flow is 0.2 MGD. Select the closest answer.

   1. 1.5 hr
   2. 1.8 hr
   3. 2.0 hr
   4. 2.4 hr
   5. 2.8 hr

15. Estimate the detention time in a sedimentation tank 90 ft long, 30 ft wide, and 12 ft deep, if the flow is 3.0 MGD. Select the closest answer.

   1. 1.5 hr
   2. 1.8 hr
   3. 2.0 hr
   4. 2.4 hr
   5. 2.8 hr

Please write on your IBM answer sheet the total time required to work all three lessons and this objective test.

OBJECTIVE TEST

Chapter 6. Trickling Filters

Name ______________________________ Date ____________

Please write your name and mark the correct answers on the IBM answer sheet as directed at the end of Chapter 1. There may be more than one answer to each question.

1. Loadings on a trickling filter may be expressed as:

    1. lb H_2O/day
    2. lb BOD/day/1000 cu ft
    3. lb H_2O/sq ft/day
    4. gal/day/sq ft
    5. gal/day/1000 cu ft

2. Masking agents:

    1. Cover the filter
    2. Mask the plant
    3. Produce desirable odors
    4. Are sprayed into the air
    5. Tend to make undesirable odors unnoticeable

3. A shock load is:

    1. A heavy blow
    2. A big load in a truck
    3. An unexpected strong waste
    4. An unexpected bump
    5. None of these

4. A flow of 1400 gpm is approximately the same as:

    1. 1 MGD
    2. 2 MGD
    3. 0.5 MGD
    4. 0.33 MGD
    5. 0.75 MGD

5. Physical methods of waste treatment include:

    1. Trickling filters
    2. Disinfection
    3. Sedimentation
    4. Screens
    5. Activated sludge

6. Before starting up a new trickling filter plant the operator should check:
    1. Oil reservoirs for proper amount and type of oil
    2. Rotation of distributor arm
    3. Underdrain system for debris
    4. Zoogleal film on filter media
    5. To be sure there are no voids in the filter media

7. In operating a trickling filter the operator should:
    1. Adjust the process to obtain the best possible results for the least cost
    2. Use the lowest recirculation rates that will yield good results to conserve power
    3. Rotate the distributor as fast as possible to better spray settled wastewater over the media
    4. Maintain aerobic conditions in the filter
    5. Bubble oxygen up through the filter

8. Which test best measures the efficiency of a trickling filter?
    1. Total solids
    2. pH
    3. BOD
    4. Temperature
    5. Sludge age

9. To correct an odor problem in a trickling filter the operator should:
    1. Take corrective action immediately
    2. Shut off flow to the filter
    3. Try to maintain aerobic conditions
    4. Check ventilation in the filter
    5. Increase recirculation rate

10. Maintenance of a distributor moved by hydraulic action includes:
    1. Cleaning the filter media
    2. Cleaning orifices in the distributor arms
    3. Changing the mercury if the distributor arm does not rotate smoothly
    4. Adjusting turnbuckles occasionally on guy rods to keep rotating arms at proper level
    5. Greasing gears that rotate distributor

11. The differences between high-rate filters and standard-rate filters include:

    1. Higher flows per day per square foot of surface area
    2. Higher pounds of BOD per day per cubic foot of media
    3. Higher BOD reductions
    4. Greater depth of filter
    5. Higher rate of odor production

12. The hydraulic loading on a trickling filter 90 feet in diameter with a flow of 0.6 MGD is approximately:

    1. 100 gpd/sq ft
    2. 95 gpd/sq ft
    3. 90 gpd/sq ft
    4. 85 gpd/sq ft
    5. None of these

13. The organic load applied to a trickling filter in pounds of BOD per day for a filter with a diameter of 75 feet, a flow of 0.4 MGD, and a filter influent BOD of 100 mg/l would be approximately:

    1. 350 lbs/day
    2. 335 lbs/day
    3. 325 lbs/day
    4. 300 lbs/day
    5. None of these

14. Successful trickling filter operation depends on:

    1. Maintenance of a chlorine residual in the effluent
    2. Washing slimes off the filter media
    3. Preventing sludge bulking
    4. Maintenance of a good growth of organisms on the filter media
    5. Filtering the solids out of the wastewater

15. The basic parts of a trickling filter include:

    1. Distribution box
    2. Distribution system
    3. Pumps
    4. Underdrain system
    5. Media

16. Problems associated with trickling filters include:

    1. Bulking
    2. Filter flies
    3. Clogging
    4. Turbid effluent
    5. Snails

17. *Trickling filtration* is a primary treatment process.

  1. True
  2. False

If wastewater recirculation rates are too low, then (18) ________

18. 1. Aerobic
  2. Anaerobic

conditions may develop in the secondary clarifier; however, if recirculation rates are too high (19) ________________

19. 1. Solids will wash out of the secondary clarifier
  2. The effluent will be sparkling clear

Please write on your IBM answer sheet the total time required to work all three lessons and this objective test.

340

OBJECTIVE TEST

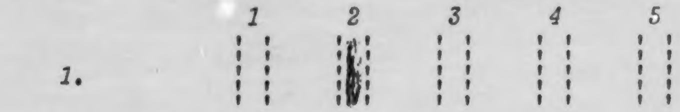
Chapter 7. Activated Sludge

Please write your name and mark the correct answers on the IBM answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to each question.

Match the word with the correct definition by marking the number of the definition on the answer sheet opposite the number of the word.

EXAMPLE

	Word		*Definition*
1.	*Plant Operator*	*1.*	*Women's Liberation advocate*
		2.	*Hard-working water quality protector*
		3.	*Uneducated individual*
		4.	*Town clown*
		5.	*None of these*



	Word		Definition
1.	Aliquot	1.	Airline schedule
2.	Coning	2.	Bacteria that have come together and formed a cluster
3.	Flights	3.	Portion of a sample
4.	Floc	4.	Scraper boards used to remove settled sludge to collection hoppers
		5.	Caused by sludge when removed too quickly
5.	Meniscus	1.	A thin plate with a hole in the middle used to measure flow
6.	Orifice	2.	Membranes in the nose and throat
7.	Protozoa	3.	Jelly-like substances of bacteria
8.	Zoogleal Mass	4.	The curved top of a column of liquid in a tube
		5.	A group of microscopic animals found in treatment processes

9. The activated sludge process:

   1. Requires aeration
   2. Requires activated carbon
   3. Is a biological process
   4. Usually follows primary sedimentation
   5. Is an anaerobic process

10. Before starting a new plant, the operator should check:

    1. The blower system
    2. Control gates and mud valves
    3. The aeration equipment
    4. For chips and scrapes on painted gates
    5. Effluent weirs for level

11. The hoist used to lift the air headers in the aeration tank must be properly anchored or it:

    1. Will float away
    2. Could fall into the aerator
    3. Won't allow even distribution of the air
    4. Could hurt someone
    5. Could not lift the aerator

12. How many pounds of solids are in a 400,000-gallon aeration tank if the suspended solids concentration is 1200 mg/1? Select the closest answer.

    1. 3600
    2. 4000
    3. 4400
    4. 4800
    5. 5200

13. When the return sludge rate is too low, what happens?

    1. The tank will not fill.
    2. There will be insufficient organisms to meet the waste load entering the aerator.
    3. The activated sludge in the aerator will starve.
    4. The activated sludge in the secondary clarifier could become septic.
    5. The sludge blanket in the secondary clarifier could become too high.

14. When operating an activated sludge plant, which is the most important suspended solids test for operational control?

    1. Primary effluent
    2. Aerator mixed liquor
    3. Return sludge
    4. Final clarifier effluent
    5. Plant influent

15. The main operational process controls available to an operator include:

1. Air rates
2. Pounds of solids under aeration
3. Maintenance
4. Return sludge rate
5. BOD test

16. What should be the waste sludge pumping rate if a plant should be wasting 2000 pounds per day and the concentration of return sludge is 5000 mg/l? Select the closest answer.

1. 30 gpm
2. 33 gpm
3. 35 gpm
4. 36 gpm
5. 40 gpm

17. What items would you check if an activated sludge plant becomes upset?

1. Influent temperature
2. Daily flow rates
3. BOD loadings
4. Digester operation
5. Chlorinator

18. How long would you allow an activated sludge process to react and stabilize after a change?

1. 3 hours
2. 12 hours
3. 1 day
4. 2 days
5. 1 week

19. Causes of sludge bulking include:

1. Bulk of sludge too large
2. Air supply too low
3. Loading rate too high
4. Aeration period too short
5. Sludge going septic in secondary clarifier

20. Package plants usually:

1. Operate the aeration device continuously
2. Have an operator at the plant 24 hours a day
3. Waste sludge out the effluent, but shouldn't when operated properly
4. Have an extensive lab testing program
5. None of these

21. The effectiveness of the organisms in the aerator depends on the:

    1. Temperature
    2. pH
    3. Presence of inhibiting substances
    4. Characteristics of food supply
    5. Time of reaction or time available for the reaction

22. What is the food/organism loading ratio in an activated sludge plant with a flow of 1 MGD? The average BOD to the aerator is 140 mg/l, the aeration tank contains 250,000 gallons, and the mixed liquor suspended solids concentration is 2000 mg/l. Select the closest answer.

    1. 25 lbs BOD per day/100 lbs MLSS
    2. 28 lbs BOD per day/100 lbs MLSS
    3. 30 lbs BOD per day/100 lbs MLSS
    4. 32 lbs BOD per day/100 lbs MLSS
    5. 35 lbs BOD per day/100 lbs MLSS

23. Why is the COD test a better operational control test than the BOD test?

    1. It isn't better.
    2. The oxygen demand is not caused by biological organisms.
    3. Everyone uses it.
    4. The results are available sooner.
    5. This chapter says so.

24. Why should all of the diffusers in an aeration tank be cleaned at once?

    1. To get the job done in a hurry
    2. So the air will flow evenly out all of the diffusers
    3. To improve step-feed aeration
    4. So the plant won't use too much air
    5. None of these

Please write on your IBM answer sheet the total time required to work Chapter 7.

OBJECTIVE TEST

Chapter 9. Waste Treatment Ponds

Please write your name and mark the correct answers on the IBM answer sheet as directed at the end of Chapter 1.

1. Ponds are used to:

   1. Store wastewater while it is treated
   2. Provide a surface for evaporation
   3. Grow mosquitoes
   4. Ice skate on
   5. Grow tules

2. When starting a pond, wastewater should be added:

   1. When the bottom is covered with grass
   2. When the pond is empty
   3. When the wind is blowing in the right direction
   4. When the mayor returns from his vacation
   5. When the pond bottom is covered with at least one foot of water.

3. Scum rafts may be broken up by:

   1. Agitation with garden rakes
   2. Jets of water from pumps
   3. The use of outboard motors on boats
   4. A thrashing machine
   5. Breaking down the bindings

4. Important operation and maintenance aspects of ponds include control of:

   1. Odors
   2. Waste gas burner
   3. Scum
   4. Drying beds
   5. Weeds and insects

5. Pond performance can be indicated by what tests?

   1. pH
   2. Carbon dioxide
   3. Methane
   4. Dissolved oxygen
   5. Hardness

6. Facultative ponds are:

   1. Faulty operating ponds
   2. Completely aerobic
   3. Aerobic on the top and anaerobic on the bottom
   4. Very shallow ponds
   5. The most common type in current use

7. Ponds may not operate properly if:

   1. The influent organic matter content fluctuates considerably every few days.
   2. Temperature stays below freezing for a long time
   3. There is no scum blanket
   4. The influent contains a powerful fungicide
   5. The influent has a high sulfur content

8. The influent to the first pond should be discharged at the:

   1. Surface
   2. Mid-depth
   3. Bottom of the pond

9. The effluent should leave the final pond:

   1. At the surface
   2. Just below the surface with a scum baffle around the outlet
   3. At the bottom of the pond

10. The pond outfall should be:

    1. Free
    2. Submerged

11. Minimum pond depth should be:

    1. 3 feet
    2. 4 feet
    3. 5 feet

12. Pond loadings may be expressed in:

    1. Acres per day of BOD
    2. Acres of people per day
    3. Pounds of BOD per acre per day
    4. Persons per acre
    5. Pounds BOD/day/acre

13. Pond performance depends on:

1. Type and quantity of algae
2. pH
3. Type of soil
4. Short circuiting
5. Surface area

14. Dissolved oxygen in a pond is increased by:

1. Surface aerators
2. Photosynthesis
3. Wind action
4. Algae liberating oxygen from the water molecule
5. Sludge gases from bottom deposits floating to the surface

15. Advantages of ponds for smaller installations include:

1. No maintenance
2. Low cost to build and operate
3. No insect problems
4. Capability to handle fluctuating loads
5. Satisfactory treatment of wastes

16. Estimate the population served if the inflow to a plant is 1.2 MGD. Assume a flow of 100 gallons per person per day.

1. 1200
2. 6000
3. 12,000
4. 120,000
5. None of these

17. Two ponds serve a summer resort and are operated in series. They cover an area of 150 ft by 250 ft (average width and length of both ponds combined). The average depth is four feet, and the average inflow is 25,000 gpd. The detention time is approximately:

1. 40 days
2. 45 days
3. 50 days
4. 55 days
5. 60 days

18. and when the influent BOD is 200 mg/l, the organic loading is approximately:

1. 40 lb BOD/day/ac
2. 42 lb BOD/day/ac
3. 45 lb BOD/day/ac
4. 48 lb BOD/day/ac
5. 50 lb BOD/day/ac

19. Ponds are __________ simple to operate. (Select best answer.)

1. Very
2. Deceptively
3. Not
4. Quite
5. Sort of

Review Question:

20. Estimate the velocity in a grit chamber if a stick travels 30 feet in 40 seconds.

1. 0.50 ft/sec
2. 0.75 ft/sec
3. 1.00 ft/sec
4. 1.25 ft/sec
5. 1.33 ft/sec

Please write on your IBM answer sheet the total time required to work all three lessons and this objective test.

OBJECTIVE TEST

Chapter 10. Disinfection and Chlorination

Name ______________________________ Date ____________

Please write your name and mark the correct answers on the IBM answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to each question.

1. Disease producing bacteria are called:
    1. Saprophytes
    2. Facultative
    3. Parasitic
    4. Pathogenic
    5. Coliform

2. Reduction in the number of pathogenic organisms in wastewater may be accomplished by:
    1. Sedimentation
    2. Prechlorination
    3. Postchlorination
    4. Providing chlorine contact time
    5. Adding orthotolidine

3. Chlorine may be applied for H_2S control in the:
    1. Collection lines
    2. Plant headworks
    3. Trickling filter
    4. Aeration tank
    5. Plant effluent

4. An operator should never enter a room containing high concentrations of chlorine gas without:
    1. Help standing by
    2. Notifying proper authorities
    3. A self-contained air or oxygen supply

5. You should never tamper with or apply heat to the fusible plug of a chlorine container.
    1. True
    2. False

6. Chlorine cylinders:

   1. Can easily be lifted by one man
   2. Can be handled safely
   3. Contain a fusible metal safety plug
   4. Should be rolled horizontally
   5. Should be stored at temperatures above 50°F and kept away from steam pipes

7. What should be the approximate chlorine feed rate for a flow of 1.5 MGD and a chlorine dosage of 15 mg/l?

   1. 200 lbs/24 hr
   2. 100 lbs/24 hr
   3. 20 lbs/24 hr
   4. 10 lbs/24 hr
   5. 2 lbs/24 hr

8. Chlorine should be applied continuously to:

   1. Keep the plant equipment from breaking down
   2. Keep the plant effluent disinfected
   3. Keep the chlorine pipes from developing leaks
   4. Keep the chlorine supplier in business
   5. Protect the downstream water users

9. Field chlorination studies have shown that:

   1. Constant vigilance is required to maintain a consistently high degree of disinfection at most wastewater treatment plants.
   2. Thorough mixing of chlorine solution with wastewater is essential to achieve maximum efficiency of coliform kill for a given chlorine dosage.
   3. Chlorine feed rates required to produce a desired disinfection level are constant from day to day.
   4. Actual contact time in most chlorine chambers is the same as the theoretical contact time.
   5. Chlorine residuals can be increased without limit and the coliform densities will always continue to be reduced with each increase in residual.

10. Chlorinators should be located:

    1. Near point of application
    2. Outdoors
    3. In a separate room
    4. In a room that will not allow chlorine to leak into rooms where operators work or where controls and equipment are located.
    5. In an adequately heated room

11. Postchlorination is generally more effective in a well-clarified effluent than in a turbid one.

    1. True
    2. False

12. Teflon tape makes a good:

    1. Joint lubricant
    2. Leak stopper

13. Hydrogen sulfide is found in most collection systems.

    1. True
    2. False

14. To protect the health of downstream water users, treatment plant effluents must be:

    1. Sterilized
    2. Disinfected

15. Hydrogen sulfide:

    1. Is associated with corrosion
    2. Causes odors
    3. Smells like chlorine
    4. Can paralyze your respiratory system
    5. Can form an explosive mixture with air

Review Questions:

A rectangular sedimentation tank 10 feet deep, 30 feet wide, and 120 feet long handles a flow of 3 MGD.

16. The detention time is:

    1. 1.5 hr
    2. 2.0 hr
    3. 2.15 hr
    4. 2.25 hr
    5. 2.5 hr

17. The surface loading rate is approximately:

    1. 500 gpd/sq ft
    2. 600 gpd/sq ft
    3. 700 gpd/sq ft
    4. 800 gpd/sq ft
    5. 900 gpd/sq ft

Please write on your IBM answer sheet the total time required to work Chapter 10.

ANSWERS TO OBJECTIVE TEST

Chapter 1. Introduction

1. 2, 3
2. 1, 2, 3
3. 1
4. 1
5. 2
6. 1

ANSWERS TO OBJECTIVE TEST

Chapter 2. Why Treat Wastes?

1. 1, 2, 3, 4
2. 1, 2, 4, 5
3. 2
4. 3
5. 1
6. 4
7. 5
8. 5
9. 2
10. 1

ANSWERS TO OBJECTIVE TEST

Chapter 3. Wastewater Facilities

1. 3
2. 1
3. 1, 3, 4
4. 2
5. 1, 2, 3, 4, 5
6. 4
7. 2
8. 1
9. 1
10. 2
11. 3

ANSWERS TO OBJECTIVE TEST

Chapter 4. Racks, Screens, Comminutors, and Grit Removal

1. 1
2. 1, 2, 3, 4, 5
3. 2
4. 1, 2
5. 3
6. 2, 3, 5
7. 2, 4
8. 4

ANSWERS TO OBJECTIVE TEST

Chapter 5. Sedimentation and Flotation

1. 1, 2, 3, 4
2. 1, 2
3. 2
4. 1, 4, 5
5. 2, 3, 4, 5
6. 1, 3, 4, 5
7. 1, 2, 4, 5
8. 2, 4
9. 1
10. 3
11. 4
12. 1, 3, 4, 5
13. 2
14. 4
15. 3

ANSWERS TO OBJECTIVE TEST

Chapter 6. Trickling Filters

1. 2, 4
2. 3, 4, 5
3. 3
4. 2

5. 3, 4
6. 1, 2, 3
7. 1, 2, 4
8. 3

9. 1, 3, 4, 5
10. 2, 4
11. 1, 2
12. 2

13. 2
14. 4
15. 2, 4, 5
16. 2, 3, 4, 5

17. 2
18. 2
19. 1

ANSWERS TO OBJECTIVE TEST

Chapter 7. Activated Sludge

1. 3
2. 5
3. 4
4. 2
5. 4
6. 1
7. 5
8. 3
9. 1, 3, 4
10. 1, 2, 3, 4, 5
11. 2, 4
12. 2
13. 2, 4, 5
14. 2
15. 1, 2, 4
16. 2
17. 1, 2, 3, 4
18. 5
19. 2, 3, 4, 5
20. 1, 3
21. 1, 2, 3, 4, 5
22. 2
23. 4
24. 2

ANSWERS TO OBJECTIVE TEST

Chapter 9. Waste Treatment Ponds

1. 1, 2
2. 5
3. 1, 2, 3
4. 1, 3, 5
5. 1, 4
6. 3, 5
7. 1, 2, 4, 5
8. 3
9. 2
10. 2
11. 1
12. 3, 4, 5
13. 1, 2, 3, 4, 5
14. 1, 2, 3, 4
15. 2, 4, 5
16. 3
17. 2
18. 4
19. 2
20. 2 Review

ANSWERS TO OBJECTIVE TEST

Chapter 10. Disinfection and Chlorination

1. 4
2. 1, 2, 3, 4
3. 1, 2
4. 1, 2, 3
5. 1
6. 2, 3, 5
7. 1
8. 2, 5
9. 1, 2
10. 1, 3, 4, 5
11. 1
12. 1
13. 1
14. 2
15. 1, 2, 4, 5
16. 3 Review
17. 4 Review

IX. DISCUSSION & REVIEW QUESTIONS AND ANSWERS

DISCUSSION AND REVIEW QUESTIONS

Chapter 4. Racks, Screens, Comminutors, and Grit Removal

DO NOT USE IBM ANSWER SHEET. Please write your answers in your notebook.

1. Why should coarse material (rocks, boards, metal, etc.) be removed at the plant entrance?
2. Why do you think the wastewater treatment and pollution control industry had a higher accident rate in 1967 than any other industry reporting to the National Safety Council?
3. What are the advantages of comminutors over screens?
4. What precautions should be taken when cleaning a grit chamber?
5. How can an operator regulate the velocity in a grit chamber?
6. A stick travels 30 feet in 50 seconds in a grit chamber. What is the flow velocity in the grit chamber? Please show your calculations in a neat fashion so someone can help you if necessary.
7. Calculate the grit removed from a grit chamber in cubic feet per million gallons if during a 24-hour period the average flow was 3 MGD and 4.5 cu ft of grit were removed.

DISCUSSION AND REVIEW QUESTIONS

Chapter 5. Sedimentation and Flotation

(End of Lesson 1 of 3 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should work before continuing. The purpose of these questions are to indicate to you how well you understand the material in this section.

1. What is the function of a primary clarifier?
2. What items should be checked before starting up a new clarifier or one which has been out of service for cleaning or repair?
3. Calculate the efficiency of a clarifier removing BOD if the influent BOD is 260 mg/l and the effluent is 155 mg/l. Show your work.
4. What would you do if the solids and BOD removal efficiencies of a primary clarifier suddenly dropped and the effluent appeared to contain more solids than usual?
5. What precautions should you take to avoid strains and overexertion when working around a treatment plant?
6. How often should sludge be pumped from a primary clarifier?

DISCUSSION AND REVIEW QUESTIONS

Chapter 5. Sedimentation and Flotation

(End of Lesson 2 of 3 Lessons)

Please write the answers to these questions in your notebook before continuing with Lesson 3. The problem numbering continues from Lesson 1.

7. Explain how temperature influences clarifier performance.
8. Draw a clarifier and indicate what is meant by short circuiting.
9. A circular clarifier has a diameter of 60 feet and an average depth of 8 feet. The flow of wastewater is 2.0 MGD. Calculate the following:
   1. Detention Time, in hours
   2. Weir Overflow Rate, in gpd/ft
   3. Surface Loading Rate, in gpd/ft^2
   4. Comment on the hydraulic loading on the clarifier.

5.10 ADDITIONAL READING

a. MOP 11, pages 25-38 and 89-97

b. New York Manual, pages 31-45

c. Texas Manual, pages 174-201

d. Sewage Treatment Practices, pages 35-47

DISCUSSION AND REVIEW QUESTIONS

Chapter 5. Sedimentation and Flotation

(End of Lesson 3 of 3 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

10. Why should floatable solids be removed from wastewater?

11. What is the critical factor in subsurface wastewater disposal systems?

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DISCUSSION AND REVIEW QUESTIONS

(Lesson 1 of 3 Lessons)

Chapter 6. Trickling Filters

Name ______________________________ Date _______________ .

Write the answers to these questions in your notebook before continuing.

1. Draw a sketch of a trickling filter and label the essential parts.
2. Why is recirculation important in the operation of a trickling filter?
3. Why should a trickling filter be carefully checked before a new one is started or an existing one is placed in service again?
4. Why would the efficiency of waste removal by a new trickling filter be low during the first few days?
5. What would you do if laboratory results or visual inspection indicated a sudden drop in efficiency of a trickling filter?
6. Calculate the suspended solids removal efficiency of a trickling filter plant if the influent suspended solids were 360 mg/l and the effluent suspended solids were 40 mg/l.
7. Why do laboratory test results for trickling filter plants vary from
   a. plant to plant?
   b. month to month within a plant?

DISCUSSION AND REVIEW QUESTIONS

(Lesson 2 of 3 Lessons)

Chapter 6. Trickling Filters

Name ______________________________ Date ____________

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

8. Define the term shock load.

9. How would you correct a ponding problem?

10. Why should a ponding problem be corrected as soon as possible?

11. What action would you take to prevent odor problems from developing in a trickling filter?

12. Why should wastewater be kept from leaking into the bearings of the distributor base?

13. Why should the flow to a trickling filter be shut off before attempting to work on the filter?

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DISCUSSION AND REVIEW QUESTIONS

(Lesson 3 of 3 Lessons)

Chapter 6. Trickling Filters

Name ______________________________ Date ____________

Write the answers to the questions before continuing. The problem numbering continues from Lesson 2.

A trickling filter is 70 feet in diameter and the depth of the media is 5 feet. The average daily flow is 2450 gpm and the BOD of the influent to the filter is 100 mg/l. Show your work and calculate:

14. Flow in gallons per day.

15. Surface area of filter.

16. Hydraulic loading.

17. BOD applied in pounds per day.

18. Volume of filter media.

19. Organic loading.

DISCUSSION AND REVIEW QUESTIONS

Chapter 7. Activated Sludge

(Lesson 1 of 8 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should work before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. Sketch the activated sludge process.
2. Define activated sludge.
3. Define facultative bacteria.
4. Some activated sludge plants do not have a primary clarifier. True or False?
5. Why must the activated sludge retention time not be too long in the final clarifier?
6. How can the operator control the activated sludge process?

DISCUSSION AND REVIEW QUESTIONS

Chapter 7. Activated Sludge

(Lesson 2 of 8 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1. Write the numbers for the correct answers to question 7 on your answer sheet in your notebook.

7. During storms an activated sludge plant will receive an increased inflow which may cause the following problems:

    1. Dilution of wastes which makes them easy to treat
    2. Reduced wastewater time in treatment units
    3. Increased amounts of grit and silt
    4. Increased organic loading
    5. Fluctuating wastewater temperatures

8. How can the operator attempt to reduce problems caused by waste discharges into the collection system?

9. How can maintenance activities in a collection system cause operational problems in an activated sludge treatment plant?

10. What can the operator determine from laboratory test results on the plant effluent?

11. What are some of the disadvantages of using the BOD test for operational control?

12. The operator of an activated sludge plant must constantly review his records and make appropriate changes to account for seasonal changes. True or False?

13. What is the difference between mechanical aeration and diffused aeration?

DISCUSSION AND REVIEW QUESTIONS

Chapter 7. Activated Sludge

(Lesson 3 of 8 Lessons)

Write the answers to these questions in your notebook before continuing . The problem numbering continues from Lesson 2.

14. What should the operator look for when checking out control gates and mud valves?

15. What happens when spray nozzles are not installed properly and spray falls on rails and walks?

16. Why should proper procedures be followed when checking equipment?

17. What safety precaution should be exercised before checking the impeller of a return sludge pump?

18. Why should the equipment manufacturer's manual be thoroughly read and understood before any equipment is started?

DISCUSSION AND REVIEW QUESTIONS

Chapter 7. Activated Sludge

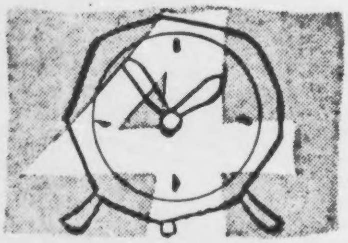
(Lesson 4 of 8 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 3.

19. When starting a new activated sludge plant, who might the operator contact for assistance and advice?

20. When starting the activated sludge process, why should you use all of the aerators and all of the secondary clarifiers?

21. What are the essential laboratory tests for starting the activated sludge process, and why?



DISCUSSION AND REVIEW QUESTIONS

Chapter 7. Activated Sludge

(Lesson 5 of 8 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 4.

22. Estimate the pounds of solids under aeration in a 200,000-gallon tank when the suspended solids concentration is 1600 mg/l. Show your work.

23. What level of dissolved oxygen should be maintained in the aeration tank during start-up?

24. What do the letters MLSS stand for?

25. Calculate the desired pounds of mixed liquor suspended solids in an aeration tank if the primary effluent suspended solids are 1800 pounds per day and the loading is based on a five-day sludge age. Show your work.

26. Calculate the desired mixed liquor suspended solids concentration (mg/l) if 4000 lbs are desired in a 200,000-gallon aeration tank. Show your work.

27. If sludge should be wasted at a rate of 0.05 MGD, what should be the waste pumping rate in GPM?

28. Why must some activated sludge be wasted?

DISCUSSION AND REVIEW QUESTIONS

Chapter 7. Activated Sludge

(Lesson 6 of 8 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 5.

29. **How would you control foaming on the aeration compartment of a package plant?**

30. **How would you operate the aeration device in a package plant?**

31. **How would you waste sludge in a package plant?**

DISCUSSION AND REVIEW QUESTIONS

Chapter 7. Activated Sludge

(Lesson 7 of 8 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 6.

32. When an activated sludge plant becomes upset, what should the operator do first?

33. Why do many activated sludge plants base aerator loadings on mixed liquor volatile suspended solids and not mixed liquor suspended solids?

34. When attempting to correct an upset activated sludge process, why should only one major change be made at a time?

35. Is sludge bulking undesirable? Why?

36. What is the purpose of the 60-minute Settleability Test?

37. Can a frothing aerator deposit grease on walks?

DISCUSSION AND REVIEW QUESTIONS

Chapter 7. Activated Sludge

(Lesson 8 of 8 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 7.

38. What is the formula for calculating the Mean Cell Residence Time?

39. Calculate the MCRT for an activated sludge process. Plant inflow is 4.0 MGD, MLSS is 2700 mg/l, waste sludge flow 0.05 MGD, total secondary system volume is 2.0 MG, waste sludge suspended solids concentration is 6500 mg/l, and final effluent suspended solids concentration is 15 mg/l.

40. Why might an operator wish to use step-feed aeration?

41. What is the name of the treatment process that is capable of producing effluents with a quality (BOD and suspended solids) between primary treatment and conventional activated sludge?

DISCUSSION AND REVIEW QUESTIONS

Chapter 9. Waste Treatment Ponds

(Lesson 1 of 3 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should work before continuing. The purpose of these questions is to indicate to you how well you understand the material in this lesson.

Write the answers to these questions in your notebook before continuing.

1. When wastewater flows through different treatment processes in a plant, where might ponds be located?
2. Why are most ponds facultative ponds?
3. Where does the oxygen in a pond come from that is produced by algae?
4. What is photosynthesis?
5. What are the three types of factors that may influence pond performance?

DISCUSSION AND REVIEW QUESTIONS

Chapter 9. Waste Treatment Ponds

(Lesson 2 of 3 Lessons)

Write the answers to these questions before continuing with Lesson 3. The problem numbering continues from Lesson 1.

6. Why should water be introduced into a new pond before any wastewater?
7. Why is good housekeeping an important factor in operating a properly functioning pond?
8. What precautions should be taken when applying an insecticide?
9. Why may chlorine compounds or chlorine solution not be the best method of odor control in a pond?
10. What lab tests measure the condition of a pond?
11. Estimate the BOD removal efficiency of a series of ponds if the influent BOD is 250 mg/l and the effluent BOD is 50 mg/l.
12. Why should fences be placed around ponds?

DISCUSSION AND REVIEW QUESTIONS

Chapter 9. Waste Treatment Ponds

(Lesson 3 of 3 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

13. Why is it desirable for a pond to be isolated?

14. How can scum be controlled from leaving a pond?

15. How can erosion of levee slopes be controlled?

A pond receives an inflow of 0.01 MGD from 100 people. The pond is 150 feet long, 150 feet wide, and 4 feet deep. Influent BOD is 200 mg/l. Determine the following loading parameters.

16. Detention Time in days

17. Population loading in persons per acre

18. Hydraulic loading in inches per day

19. Organic loading in pounds of BOD applied per day per acre

DISCUSSION AND REVIEW QUESTIONS

Chapter 10. Disinfection and Chlorination

(Lesson 1 of 4 Lessons)

At the end of each lesson in this chapter you will find discussion and review questions that you should work before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson.

Write the answers to these questions in your notebook before continuing.

1. Why must wastewaters be disinfected?
2. Why is chlorination used to disinfect wastewater?
3. To improve disinfection, which is more effective--increasing the chlorine dose, or extending the chlorine contact time?
4. What constituents in wastewater are mainly responsible for the chlorine demand?
5. Calculate the chlorinator setting (lbs per 24 hours) to treat a waste with a chlorine demand of 12 mg/l, when a chlorine residual of 2 mg/l is desired, if the flow is 1 MGD.
6. How do suspended and dissolved organic compounds in an effluent affect disinfection?

DISCUSSION AND REVIEW QUESTIONS

Chapter 10. Disinfection and Chlorination

(Lesson 2 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

7. Where might chlorine be applied in the treatment of wastewater?
8. Where is chlorine usually applied for disinfection purposes?
9. What is the ultimate control of chlorine dosage for disinfection?
10. Determine the chlorine feed rate for a flow of 0.75 MGD and a chlorine dosage of 18 mg/l.
11. Why must the chlorine solution be well mixed with the wastewater?

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DISCUSSION AND REVIEW QUESTIONS

Chapter 10. Disinfection and Chlorination

(Lesson 3 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

12. What type of breathing apparatus should be worn when entering an area in which chlorine gas is present?

13. Why should clothing be removed from a person who has been in an area contaminated with liquid or gaseous chlorine?

14. How could your police department assist you in the event of a serious chlorine leak?

15. Why should chlorine containers and cylinders be stored where they won't be heated?

16. Why are slings used to hold chlorine tubing when changing chlorine cylinders?

17. Why should water never be poured on a chlorine leak?

18. How would you attempt to repair a pin hole leak in a chlorine cylinder?

DISCUSSION AND REVIEW QUESTIONS

Chapter 10. Disinfection and Chlorination

(Lesson 4 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 3.

19. How is the rate of chlorine gas flow in a chlorinator controlled?

20. How often should the weights of chlorine cylinders be recorded?

21. Why must chlorination be continuous?

22. Why should the temperature of chlorine piping and control equipment be higher than the temperature of the chlorine containers?

23. Why must direct cross-connections be avoided between a public water supply and the injector water supply?

24. What is "sub-residual chlorination"?

25. Why should sulfides be controlled?

ANSWERS TO QUESTIONS

Chapter 4. Racks, Screen, Comminutors, and Grit Removal

1. Coarse material should be removed at the plant entrance to prevent plugging of pipes, damaging of pumps, and hindrance of treatment processes.

2. High accident rate could have been due to lack of knowledge, awareness of dangers, correction of hazardous conditions, and not practicing safe procedures. (Any opinion OK).

3. Comminutors shred the solids and leave them in the wastewater, thus overcoming the problem of screening disposal.

4. When cleaning a grit chamber, precaution should be taken to avoid slipping or straining your back.

5. The velocity in a grit chamber can be increased by placing boards in the chamber to reduce the cross-sectional area. To decrease the velocity, another grit chamber will have to be put in service if available. Proportional weirs also are used to regulate velocities in a grit chamber.

6. $$\text{Velocity, ft/sec} = \frac{\text{Distance ft}}{\text{Time, sec}}$$

$$= \frac{30\text{ ft}}{50\text{ sec}}$$

$$= \underline{0.6}\text{ ft/sec}$$

7. $$\text{Grit Removed, ft}^3\text{ 3/MG} = \frac{\text{Grit Removed, ft}^3\text{ /day}}{\text{Flow, MGD}}$$

$$= \frac{4.5\text{ ft}^3\text{ /day}}{3\text{ MG/day}}$$

$$= \underline{1.5\text{ ft}^3\text{ /MG}}$$

ANSWERS TO QUESTIONS

Chapter 5. Sedimentation and Flotation

Lesson 1

1. The function of the primary clarifier is to remove settleable and floatable solids.

2. Before starting a clarifier, the operator should check:

   a. remove objects that may be harmful to equipment or plug piping
   b. lubricate equipment
   c. check meters and machinery for proper operation.

3. Find BOD efficiency of clarifier if influent is 260 mg/l and effluent 155 mg/l.

$$\text{Efficiency, \%} = \frac{(\text{In} - \text{Out})}{\text{In}} \times 100\%$$

$$= \frac{(260 \text{ mg/l} - 155 \text{ mg/l})}{260 \text{ mg/l}} \times 100\%$$

$$= 40.5\%$$

4. Look for source of problem causing the poor quality effluent by checking:

   a. Influent, characteristics and flow
   b. Clarifier, skimmer and ploughs working
   c. Scum and sludge pumps
   d. Pipes

5. Strains and overexertion may be avoided by using proper tools and equipment.

6. Sludge should be pumped from the clarifier at regular intervals and often enough to prevent septic conditions.

ANSWERS TO QUESTIONS

Chapter 5. Sedimentation and Flotation

(Lesson 2 of 3 Lessons)

7. Temperature influences clarifier performance by changing the density of the wastewater. The warmer the water, the lighter and thus, the better solids will settle.

8. Short circuiting, see page 5-29, Fig. 5.7.

9. D = 60 ft H = 8 ft Q = 2 MGD

$$\text{Area} = \frac{\pi}{4} D^2 = \frac{\pi}{4} (60 \text{ ft})^2 = 2830 \text{ sq ft}$$

$$= (2830 \text{ sq ft})(8 \text{ ft}) = 22{,}600 \text{ cu ft}$$

$$= (22{,}600 \text{ cu ft})(7.5 \text{ gal/cu ft})$$

$$= 169{,}000 \text{ gal}$$

1) Find Detention Time

$$\text{Detention Time, hr} = \frac{(\text{Volume, gal})(24 \text{ hr/day})}{\text{Flow, gal/day}}$$

$$= \frac{(169{,}000 \text{ gal})(24 \text{ hr/day})}{2{,}000{,}000 \text{ gal/day}}$$

$$= 2.0 \text{ hr}$$

Acceptable range is 2 to 3 hours

2) Find Weir Overflow

$$\text{Weir Overflow, gpd/sq ft} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

$$= \frac{2{,}000{,}000 \text{ gpd}}{\pi (60 \text{ ft})}$$

$$= 10{,}600 \text{ gpd/ft}$$

Accepted range is 10,000 to 20,000

3) Find Surface Loading, gpd/sq ft

$$\text{Surface Loading gpd/sq ft} = \frac{\text{Flow, gpd}}{\text{Area, sq ft}}$$

$$= \frac{2{,}000{,}000 \text{ gpd}}{2830 \text{ sq ft}}$$

$$= 708 \text{ gpd/sq ft}$$

Accepted range is 500 to 1800 gpd/sq ft.

4) Comments.

All loadings are within usual design ranges.

Chapter 5. Sedimentation and Flotation

Lesson 3

10. Floatable solids should be removed from wastewater to improve the aesthetics of the receiving waters.

11. The critical factor in subsurface wastewater disposal systems is the ability of the soil mantle to leach the septic tank effluent.

ANSWERS TO QUESTIONS

(Lesson 1 of 3 Lessons)

Chapter 6. Trickling Filters

1. Draw a sketch of a trickling filter and label the essential parts. See Fig. 6.3.

2. Recirculation is important in trickling filter operation because it is a method of improving efficiency by recycling the treated wastewater and thus increasing the contact time of the wastewater with the biological slime on the media. Recirculation prevents excessive slime growths and helps to control snail and fly populations in the filter.

3. Before starting a trickling filter it should be checked to be certain all the essential parts will work properly when wastewater is applied.

4. Low efficiencies of waste removal by a new trickling filter are caused by the fact that slime growths have not built-up on the media.

5. If lab results indicate a loss of efficiency by a trickling filter, the cause should be identified and corrected if possible. Items checked include influent flow and characteristics and the state (health) and operation of the filter.

6. Suspended Solids Efficiency, %

$$= \frac{(\text{In} - \text{Out})}{\text{In}} \times 100\%$$

$$= \frac{(360 \text{ mg/l} - 40 \text{ mg/l})}{360 \text{ mg/l}} \times 100\%$$

$$= 88.9\%$$

7. Lab test results will vary from

   (1) Plant to plant because of different influent characteristics and the ability of the slime growths to treat the wastewater.

   (2) Month to month due to changes in the influent and changes in the slime organisms due to seasonal changes in the climate and influent.

ANSWERS TO QUESTIONS

(Lesson 2 of 3 Lessons)

Chapter 6. Trickling Filters

8. Shock Load: The arrival at a plant of a waste which is toxic to organisms in sufficient quantity or strength to cause operating problems, such as odors or sloughing off of the growth or slime on the trickling filter media. Organic or hydraulic overloads also can cause a shock load.

9. To correct a ponding problem the cause must be identified and corrected. Ponding may be controlled by jetting the problem area with a high pressure water stream, hand turning or stirring the filter surface, dosing the filter with chlorine, flooding the filter, or shutting off the flow and causing the growth to dry.

10. A ponding problem should be corrected as soon as possible to prevent a lowering of the quality of the effluent water. When ponding becomes serious the efficiency of the plant drops considerably, and drastic control measures such as flooding the filter or shutting off the flow will cause a poor quality of effluent when flow is started again.

11. Odor problems may be prevented by maintaining aerobic conditions in the collector system, allowing natural ventilation of the filter, and properly regulating the recirculation rate.

12. Wastewater should be kept from leaking into the bearings of the distributor base because the wastewater will foul the bearings and the distributor will not rotate smoothly and distribute the wastewater evenly over the filter media.

13. The flow to a trickling filter must be shut off before attempting to work on the filter because if the distributor arms are rotating they can seriously injure an operator.

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ANSWERS TO QUESTIONS

(Lesson 3 of 3 Lessons)

Chapter 6. Trickling Filters

Given: Trickling Filter

Diameter = 70 ft Flow = 2450 gpm
Depth = 5 ft BOD = 100 mg/l

14. Flow, gpd

$$\text{Flow, gpd} = \frac{(\text{Flow, gpm})\ (1{,}000{,}000\ \text{gpd})}{700\ \text{gpm}}$$

$$= \frac{(2450\ \text{gpm})\ (1{,}000{,}000\ \text{gpd})}{700\ \text{gpm}}$$

$$= 3{,}500{,}000\ \text{gpd}$$

15. Surface Area, sq ft

$$\text{Surface Area, sq ft} = \left(\frac{\pi}{4}\right)(\text{Diameter, ft})^2$$

$$= (0.785)\ (70\ \text{ft})^2$$

$$= 3846\ \text{sq ft}$$

16. Hydraulic Loading, gpd/sq ft

$$\text{Hydraulic Loading, gpd/sq ft} = \frac{\text{Flow, gpd}}{\text{Surface Area, sq ft}}$$

$$= \frac{3{,}500{,}000\ \text{gpd}}{3846\ \text{sq ft}}$$

$$= 910\ \text{gpd/sq ft}$$

17. BOD Applied, lbs/day

$$\text{BOD Applied, lbs/day} = (\text{BOD, mg/l})\ (\text{Flow, MGD})\ (8.34\ \text{lb/gal})$$

$$= \left(100\ \frac{\text{mg}}{\text{M mg}}\right)\left(\frac{3.5\ \text{M Gal}}{\text{Day}}\right)\left(\frac{8.34\ \text{lb}}{\text{Gal}}\right)$$

$$= 2919\ \text{lb/day}$$

18. Volume of Filter Media, cu ft = (Surface Area, sq ft) (Depth, ft)

= (3846 sq ft) (5 ft)

= 19,230 cu ft

= 19.2 (1000 cu ft)

19. Organic Loading, lb BOD/day/1000 cu ft $= \frac{\text{BOD Loading, lb/day}}{\text{Volume Filter, 1000 cu ft}}$

$= \frac{\text{2919 lb/day}}{\text{19.2 (1000 cu ft)}}$

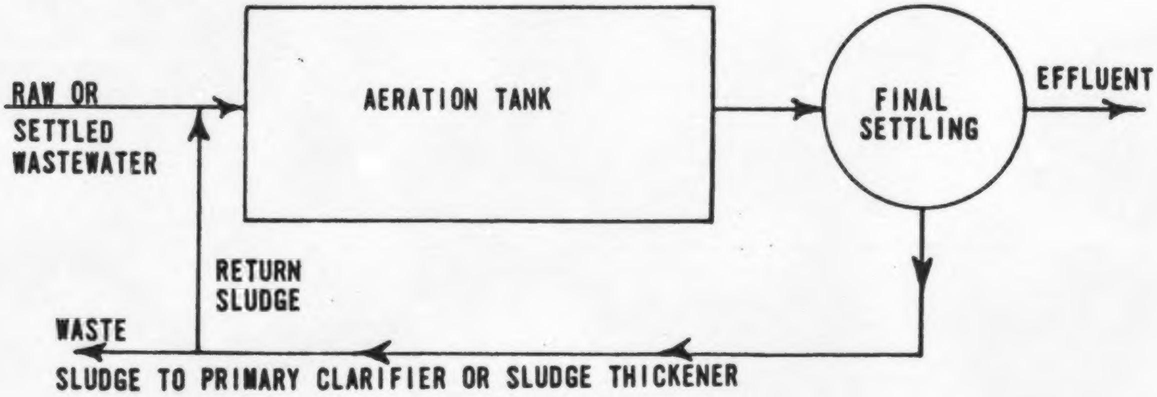
= 152 lb BOD/day/1000 cu ft

ANSWERS TO QUESTIONS

Chapter 7. Activated Sludge

(Lesson 1 of 8 Lessons)

1. Sketch the activated sludge process.


RAW OR
SETTLED
WASTEWATER
AERATION TANK
FINAL
SETTLING
EFFLUENT
RETURN
SLUDGE
WASTE
SLUDGE TO PRIMARY CLARIFIER OR SLUDGE THICKENER

2. Activated sludge consists of sludge particles produced in raw or settled wastewater (primary effluent) by the growth of organisms in aeration tanks in the presence of dissolved oxygen.

3. Facultative bacteria can use either molecular (dissolved) oxygen or oxygen obtained from food materials.

4. True.

5. Activated sludge in the final clarifier are in a deteriorating condition because of a lack of oxygen and food and should be returned to the aeration tank as soon as possible.

6. An operator can control the activated sludge process by maintaining the solids level in the aeration tank that produces the best effluent and the DO level above 2 mg/l.

ANSWERS TO QUESTIONS

Chapter 7. Activated Sludge

(Lesson 2 of 8 Lessons)

7. 2, 3, 4, and 5.

8. The operator can attempt to reduce problems caused by waste discharges in the collection system by becoming acquainted with the managers of plants who may discharge troublesome wastes and urging them to cooperate and properly regulate their discharges.

9. Maintenance activities in a collection system can cause operational problems by clearing a pipeline blockage or holding flows and then releasing them immediately after a pumping station has been put back on the line. Releases of large volumes of septic wastewater could cause a shock load on the treatment processes.

10. Laboratory test results on the plant effluent can indicate to the operator whether or not the treatment processes are functioning properly and also if he is meeting the discharge requirements.

11. Some of the disadvantages of using the BOD test for operational control include:
    1. Test results are not available for five days.
    2. Procedural errors can cause a large variation in results.
    3. Only a portion of the load on the activated sludge process is measured by the test.

12. True.

13. The difference between mechanical aeration and diffused aeration is that with mechanical aeration the aeration mechanisms are at or in the aerator, while with diffused aeration the source of air is at a remote location.

ANSWERS TO QUESTIONS

Chapter 7. Activated Sludge

(Lesson 3 of 8 Lessons)

14. When checking out control gates and mud valves, the operator should look for foreign materials that will bend the threads on the stem, or material such as paint or dirt that will get in the slides and not allow the valve to seat properly or operate smoothly.

15. When spray nozzles are not installed properly they do not dissipate foam, and spray on rails and walks can create slippery conditions due to the formation of algae or ice.

16. Proper procedures must be followed when checking equipment or you could lose your warranty and your agency would have to pay the costs of repairs and replacement parts.

17. Before checking the impeller of any pump, the motor should be locked out at the power panel so it can't be started and tagged, indicating who locked it out and when.

18. The equipment manufacturer's manual must be thoroughly read and understood before any equipment is started to avoid possible damage to the equipment or injury to the operator during start-up and operation.

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ANSWERS TO QUESTIONS

Chapter 7. Activated Sludge

(Lesson 4 of 8 Lessons)

19. Assistance and advice on starting a new activated sludge plant may be available from vendors, the consulting engineer, nearby operators, or other specialists.

20. When starting the activated sludge process, all of the aerators should be placed in service to provide the longest possible aeration time. This aeration time is used to develop a population of organisms and give them a chance to reach the settling stage. All of the clarifiers are needed to reduce washout of rapidly growing organisms needed for solids build-up in the aerator.

21.

Test	Reason
BOD and COD	Determine load (food) on system.
Mixed Liquor Suspended Solids	Observe solids build-up in aerator and develop proper food (COD or BOD) to organisms (solids) ratio.
Dissolved Oxygen	Maintain aerobic conditions in aerator.
60-Minute Settleability Test	Observe settling characteristics of activated sludge.

ANSWERS TO QUESTIONS

Chapter 7. Activated Sludge

(Lesson 5 of 8 Lessons)

22. Estimate the pounds of solids under aeration in a 200,000-gallon tank when the suspended solids is 1600 mg/l.

$$\text{Solids, lbs} = \text{Solids Conc, mg/l} \times \text{Vol, M Gal} \times 8.34 \text{ lbs/gal}$$

$$= 1600 \text{ mg/l} \times 0.2 \text{ M Gal} \times 8.34 \text{ lbs/gal}$$

$$= 2670 \text{ pounds}$$

23. During start-up the DO in the aerator should be around 2.0 mg/l.

24. Mixed Liquor Suspended Solids.

25. $$\text{Desired Mixed Liquor Suspended Solids} = (\text{Sludge Age, days})\ (\text{Susp. Solids in Prim. Effl., lbs/day})$$

$$= (5 \text{ days})\ (1800 \text{ lbs/day})$$

$$= 9000 \text{ lbs MLSS}$$

26. $$\text{Desired MLSS, mg/l} = \frac{\text{Weight of MLSS, lbs}}{\text{Weight of Aeration Tank Liquor, lbs}}$$

$$= \frac{4000 \text{ lbs}}{200{,}000 \text{ gal} \times 8.34 \text{ lbs/gal}}$$

$$= \frac{4000 \text{ lbs}}{1{,}668{,}000 \text{ lbs}} = \frac{2400 \text{ lbs}}{\text{million lbs}}$$

$$= 2400 \text{ mg/l}$$

27. $$\text{Waste Pumping Rate, GPM} = \frac{\text{Waste Rate, gal/day}}{24 \text{ hour/day} \times 60 \text{ min/hour}} = \frac{50{,}000 \text{ gal/day}}{1440 \text{ min/day}}$$

$$= 35 \text{ GPM}$$

28. Some activated sludge must be wasted to maintain the proper sludge age or solids concentration in the aerator.

ANSWERS TO QUESTIONS

Chapter 7. Activated Sludge

(Lesson 6 of 8 Lessons)

29. Foaming may be controlled in a package plant by spraying the foam with a garden hose.

30. The aeration device is operated by adjusting the air rates until the solids settle properly. When the water in the aeration tank is murky or cloudy and has a rotten egg odor, then the air supply should be increased slightly each day until the water is clear in the settling compartment.

31. To waste sludge in a package plant, turn off the return pumps or air lifts for two hours and continue to let the rest of the plant function. After two hours, remove approximately 5% of the solids in the bottom of the settling compartment.

ANSWERS TO QUESTIONS

Chapter 7. Activated Sludge

(Lesson 7 of 8 Lessons)

32. When an activated sludge plant becomes upset, the first action by the operator should be to review the plant data for the previous three weeks to look for the cause of the upset.

33. Many plants base aerator loading on mixed liquor volatile suspended solids loadings on the assumption that the volatile portion of the solids represents the microorganisms while the total mixed liquor suspended solids contains inert material. Sources of inert material include digester supernatant and storm water solids (sand).

34. When attempting to correct an upset activated sludge process, only one major change should be made at a time in order to evaluate the influence of the change. If more than one change is made, the operator won't know which change was effective or ineffective.

35. Yes. Sludge bulking refers to a condition in which solids leave the process in the plant effluent and adversely influence the receiving waters.

36. The purpose of the settleability or 60-Minute Settleability Test is to indicate the expected settling characteristics of activated sludge in the secondary clarifier.

37. Yes. A frothing aerator can deposit grease on walks.

ANSWERS TO QUESTIONS

Chapter 7. Activated Sludge

(Lesson 8 of 8 Lessons)

38. $$\text{MCRT, days} = \frac{\text{Susp. Solids in Total Secondarys System, lbs}}{\text{Susp. Solids Wasted, lbs/day} + \text{Susp. Solids Lost in Effl, lbs/day}}$$

39. $$\text{MCRT, days} = \frac{\text{Susp. Solids in Total Secondary System, lbs}}{\text{Susp. Solids Wasted, lbs/day} + \text{Susp. Solids Lost in Effl, lbs/day}}$$

$$= \frac{2700\ \text{mg/l} \times 2.0\ \text{MG} \times 8.34\ \text{lbs/gal}}{(6500\ \text{mg/l} \times 0.05\ \text{MGD} \times 8.34\ \text{lbs/gal}) + (15\ \text{mg/l} \times 4.0\ \text{MGD} \times 8.34\ \text{lbs/gal})}$$

$$= \frac{45{,}036\ \text{lbs}}{2711\ \text{lbs/day} + 500\ \text{lbs/day}}$$

$$= 14.1\ \text{days}$$

40. When influent strength (food) increases, the average solids loading in the aerator must be increased. This can cause a solids overload in the final clarifier, and step-feed aeration is capable of relieving the solids load on the overloaded clarifier.

41. Modified aeration.

ANSWERS TO QUESTIONS

Chapter 9. Waste Treatment Ponds

(Lesson 1 of 3 Lessons)

1. As wastewater flows through different treatment processes in a plant, raw wastewater (sewage) lagoons could be the first treatment process wastewater might encounter. Ponds also could be located after a primary clarifier or sedimentation tank (oxidation pond) or after a trickling filter (polishing pond).

2. Most ponds are faculatative ponds because it is almost impossible to maintain completely aerobic or anaerobic conditions all the time at all depths of a pond.

3. Oxygen in a pond comes from algae liberating oxygen in the water (H_2O) molecule.

4. Photosynthesis is a process in which organisims with the aid of chlorophyll (green plant tissue) convert carbon dioxide and inorganic substances to oxygen and additional plant material, utilizing sunlight for energy. Land plants grow by the same process.

5. The three types of factors that may influence pond performance are: (1) physical, (2) chemical, and (3) biological.

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ANSWERS TO QUESTIONS

Chapter 9. Waste Treatment Ponds

(Lesson 2 of 3 Lessons)

6. Water should cover the first foot of a new pond before any wastewater is introduced to prevent odor problems that could be caused by the decomposition of solids exposed to the atmosphere.

7. Good housekeeping is an important factor in operating a properly functioning pond because many complaints about ponds originate from poor housekeeping practices.

8. Before applying an insecticide, the pond should be lowered in order to hold the contents for at least one day to minimize the effect of the insecticide on the receiving water. Insecticides should be applied on a calm day.

9. Chlorine compounds or chlorine solution may not be the best method of odor control in a pond because they may interfere with the biological activity.

10. The condition of a pond is measured by the temperature, pH, and DO lab tests.

11. BOD Removal, %

$$= \frac{(\text{In} - \text{Out})}{\text{In}} \times 100\%$$

$$= \frac{(250\text{ mg/l} - 50\text{ mg/l})}{250\text{ mg/l}} \times 100\%$$

$$= \frac{200\text{ mg/l}}{250\text{ mg/l}} \times 100\%$$

$$= 0.80 \times 100\%$$

$$= 80\%$$

12. Fences should be placed around ponds to keep unauthorized persons and animals out of the pond area. They should be located where they will not interfere with plant operation and maintenance.

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ANSWERS TO DISCUSSION AND REVIEW QUESTIONS

Chapter 9. Waste Treatment Ponds

(Lesson 3 of 3 Lessons)

13. Ponds should be isolated to prevent nuisances such as odors and insects associated with ponds from disturbing residential, commercial, and recreational neighbors, as well as to prevent possible traffic hazards from insects.

14. Scum can be controlled from leaving a pond by using a submerged inlet (just below the surface) and by placing a scum baffle around the inlet and periodically removing any collected scum.

15. Erosion of levee slopes can be controlled by protecting the slopes with rocky material or riprap. Trees can be planted to provide an eventual wind break.

16. Q = 0.01 MGD; BOD = 200 mg/l; Pond L = 150 ft, W = 150 ft. H = 4 ft.

$$\text{Pond Area, ac} = \frac{\text{Length, ft} \times \text{Width, ft}}{43{,}560 \text{ sq ft/ac}}$$

$$= \frac{150 \text{ ft} \times 150 \text{ ft}}{43{,}560 \text{ sq ft/ac}}$$

$$= 0.52 \text{ ac}$$

$$\text{Pond Volume, ac-ft} = \text{Area, ac} \times \text{Depth, ft}$$

$$= 0.52 \text{ ac} \times 4 \text{ ft}$$

$$= 2.08 \text{ ac-ft}$$

Convert inflow from MGD to ac-ft.

$$\text{Flow, ac-ft/day} = \frac{10{,}000 \text{ gal/day}}{7.5 \text{ gal/cu ft} \times 43{,}560 \text{ sq ft/ac}}$$

$$= 0.031 \text{ ac-ft/day}$$

Determine detention time in days.

$$\text{Detention Time, days} = \frac{\text{Pond Volume, ac-ft}}{\text{Flow Rate, ac-ft/day}}$$

$$= \frac{2.08 \text{ ac-ft}}{0.031 \text{ ac-ft/day}}$$

$$= 67 \text{ days}$$

17. Determine population loading.

$$\text{Population Loading, persons/ac} = \frac{\text{Population, persons}}{\text{Area, ac}}$$

$$= \frac{100 \text{ persons}}{0.52 \text{ ac}}$$

$$= 192 \text{ persons/ac}$$

18. Determine the hydraulic loading.

$$\text{Hydraulic Loading, in/day} = \frac{\text{Pond Depth, in}}{\text{Detention Time, days}}$$

$$= \frac{4 \text{ ft} \times 12 \text{ in/ft}}{67 \text{ days}}$$

$$= 0.73 \text{ in/day}$$

19. Determine organic loading.

$$\text{Organic Load, lb BOD/day/ac} = \frac{(\text{BOD, mg/l})(\text{Flow, MGD})(8.34 \text{ lbs/gal})}{\text{Area, ac}}$$

$$= \frac{(200 \text{ mg/l})(0.01 \text{ MGD})(8.34 \text{ lbs/gal})}{0.52 \text{ ac}}$$

$$= 32 \text{ lb BOD/day/ac}$$

ANSWERS TO QUESTIONS

Chapter 10. Disinfection and Chlorination

(Lesson 1 of 4 Lessons)

1. Wastewaters must be disinfected to kill pathogenic organisms and thus prevent the spread of water-borne diseases.

2. Chlorination is used to disinfect wastewaters because it is an effective disinfectant, and it is economical in comparison with other chemicals.

3. To improve disinfection, for most wastewaters extending chlorine contact time can be more effective than increasing dosages.

4. A chlorine demand is caused in wastewater by the wastes (reducing compounds) in the water which react with chlorine, such as hydrogen sulfide, thiosulfates, ferrous iron, nitrogenous compounds, and organic matter.

5. Chlorine Dose, mg/l = Chlorine Demand, mg/l + Chlorine Residual, mg/l

   = 12 mg/l + 2 mg/l

   = 14 mg/l

   Chlorinator Setting, lbs/day = Chlorine Dose, mg/l x Flow, MGD x 8.34 lbs/gal

   $$= \frac{14 \text{ lbs}}{\text{M lbs}} \times \frac{1 \text{ M Gal}}{\text{day}} \times 8.34 \text{ lbs/gal}$$

   = 117 lbs/24 hr

6. Large amounts of suspended and dissolved organic compounds in an effluent increase the chlorine demand and tend to make the coliform test results more erratic.

ANSWERS TO QUESTIONS

Chapter 10. Disinfection and Chlorination

(Lesson 2 of 4 Lessons)

7. Chlorine might be applied up-sewer, before the plant (prechlorination), in the plant, or after the other treatment processes (postchlorination) to treat wastewater.

8. Chlorine is usually applied after the other treatment processes for disinfection purposes.

9. Ultimate control of chlorine dosage depends on the results desired, the bacterial level or concentration acceptable or permissible at the point of discharge.

10. Q = 0.75 MGD. From chart, chlorine dose = 0.18 mg/l.

Then, Chlorine Feed Rate = 1.1 lbs/24 hours

For 18 mg/l, Chlorine Feed Rate = 110 lbs/24 hours

or

Chlorine Feed Rate, lbs/day = Chlorine Dose, mg/l x Flow, MGD x 8.34 lbs/gal

= 18 mg/l x 0.75 MGD x 8.34 lbs/gal

= 112 lbs/24 hours

11. Mixing of the chlorine solution with wastewater is for effective disinfection and consistent results.

ANSWERS TO QUESTIONS

Chapter 10. Disinfection and Chlorination

(Lesson 3 of 4 Lessons)

12. A self-contained air or oxygen supply type breathing apparatus should be worn when entering an area containing chlorine gas.

13. Clothing must be removed from a person who has been in an area contaminated with liquid or gaseous chlorine because the clothing will continue to give off chlorine gas and irritate the body even after leaving the area.

14. During a serious chlorine leak, the police department could block off roads and help evacuate neighbors if necessary.

15. If a chlorine cylinder is heated, the gas will expand and the fusible plug could melt or other leaks could develop.

16. A sling will hold the chlorine tubing and prevent it from flopping around and getting kinked or getting dirt in it while cylinders are being changed.

17. Water should never be poured on a chlorine leak because when mixed with chlorine gas the resulting solution is very corrosive and the leak will become worse.

18. A pin hole leak in a chlorine cylinder may be repaired using a clamping pressure saddle available in repair kits.

ANSWERS TO QUESTIONS

Chapter 10. Disinfection and Chlorination

(Lesson 4 of 4 Lessons)

19. The rate of chlorine gas flow in a chlorinator is controlled by a V-notch variable orifice.

20. The weights of chlorine cylinders should be recorded daily.

21. Chlorination must be continuous because the plant effluent must be disinfected at all times to protect downstream water users.

22. The temperature of the chlorine piping and control equipment should be higher than the temperature of the chlorine containers to prevent reliquefaction.

23. Direct cross-connections must be avoided between a public water supply and the injector water supply to prevent possible contamination of the public water supply.

24. "Sub-residual chlorination" is the application of chlorination at levels well below the chlorine demand point for the purpose of sulfide control.

25. Sulfides should be controlled because they cause foul-smelling odors, form explosive mixtures, paralyze your respiratory tract, and are corrosive.